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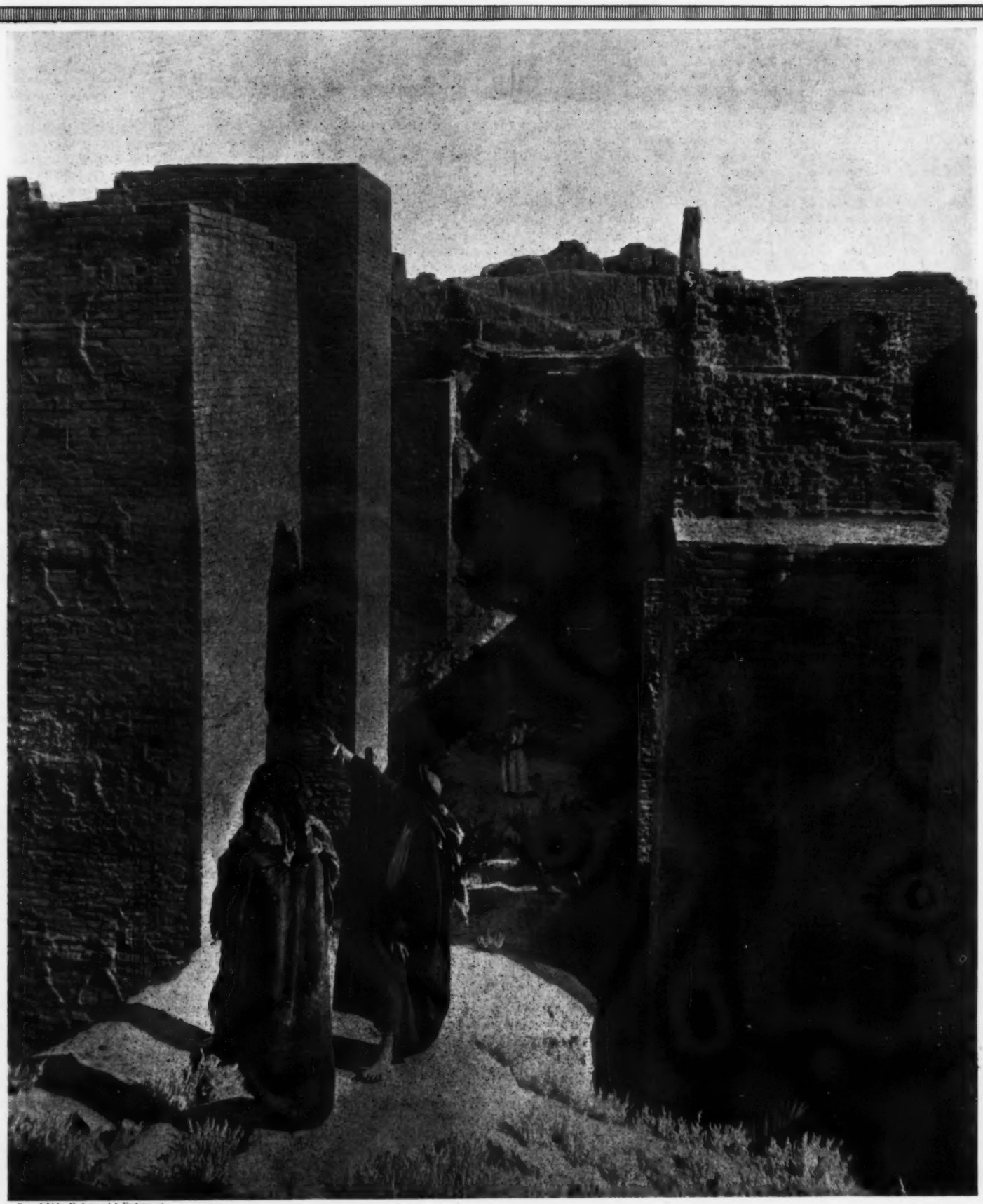

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The Triumphal Gateway of the goddess Ishtar and the processional road of the god Marduk. The gateway consists of six square pillars, three on each side, forty feet high and twelve feet broad. In the background is the mound of Kasr, or the royal city mound of Nebuchadnezzar.

EXCAVATING BURIED BABYLON.—[See pages 66, 72 and 73.]

The Resurrection of Babylon*

Extensive Work That Has So Far Proved Disappointing

THOUGH scarcely a book to attract the general reader, Dr. Koldewey's[1] account of the German excavations on the mounds which have for ages entombed the remains of Babylon the Great, is a work of considerable importance for all who are interested in the archæology of the Old Testament. This, as perhaps is not generally known in England, is still a growing science; and the worst thing that can be said of the German Expedition to Babylonia is that, after so many years of patient and persistent spadework on one of the most promising sites in the world, it has not yet succeeded in unearthing anything of higher historical or religious value than is recorded in the volume before us. Nothing extraordinary has hitherto been found; no great literary monument, no document of supreme religious moment, nothing that lends decisive help toward the settlement of any one of the unsolved problems of history or chronology. How much more fortunate in this respect were the pioneering labors of Layard and George Smith and Botta at Nineveh, of Rassam at Sippara, of De Sarzec at Tellô, of De Morgan and Scheil at Susa!

It is well for us that the Assyrian kings were so deeply interested in the literary monuments of Babylon. Had we depended for our knowledge of these on the remains of the Great City itself, we should (until the recent American discoveries at Nippur) have been left without any indication of the existence of the Babylonian legends of Creation and the Deluge; to say nothing of the many relics of the arts and sciences of Babylon which the library of Assurbanipal preserved for us.

The pathos of the position of the German explorers was that the site had been looted so often previously to their systematic investigations that scarcely anything of first-rate importance was left for the latest adventurers. The temples and palaces of Nebuchadnezzar's capital were probably swept bare of most of their portable treasures at a comparatively early period; and the ravages of people in search of building material, and the petty pilferings of Arabs and other stray visitors, had doubtless robbed the ruins of much that would have been priceless in the eyes of modern explorers. Even the beautiful enameled bricks, with their strange mythological figures, are not altogether a novelty. Older specimens of the same kind of mural decoration were long ago reproduced by Perrot and Chipiez from Sargon's palace at Khorsabad ("History of Art in Chaldea and Assyria," II., plate xv.; see also plates xiii-xiv. Eng. Trans., London, 1884). But it is highly satisfactory to find such splendid examples as those of the Ishtar Gate still existing, *in situ*, and in such an excellent state of preservation (see cover illustration).

Whether anything of supreme value awaits disinterment at lower levels remains to be seen. Slabs of diorite or other hard stone, like the famous stela of Hammurabi, or the similarly written inscription of Nebuchadnezzar, which is (or was) one of the treasures of the library of the East India House, might well have survived an age-long immersion in Euphratean mud. In any case, disappointing as, in such respects, results have hitherto proved to be, we entirely agree with Dr. Koldewey that it is most desirable that the work of excavating this historic site, begun so many years ago, should be carried to completion. Meanwhile, the special student will not fail to find many good things in this storehouse of facts and comments. It is now certain that ancient accounts greatly exaggerated the extent of ground actually covered by the city, the influence of which dominated the civilized world from the age of Hammurabi, the founder of its imperial greatness, to that of Nebuchadnezzar, who, if he did not find it of brick and leave it of marble, undoubtedly restored and enlarged its walls and temples and palaces on so grand a scale that the glories of Babylon the Great became a standing wonder of antiquity. The walls, however, have been found to range from upward of fifty to more than sixty feet in thickness, and the mounds which concealed them rose to about four times the height of the ordinary *Tels* of buried Oriental cities; circumstances which sufficiently indicate the arduous nature of the task of excavation.

We must be excused if we demur to the transcription "Sirrush" and the explanation "a walking serpent" (p. 46). The Cirrush, or rather, mush-rush, was one of the aqueous monsters created by Tiâmat, to help her in warring down the gods of light. It is something to learn what a mush-rush was like; and Dr. Koldewey has enabled us to identify it with a form already familiar to us from other Babylonian monuments. It was, in fact, not so much a serpent (though the Sumerian mush includes that meaning) as a composite form with serpent head, scales, and tail, and four claw-footed legs—a sort of "laidly worm" or "fearsome dragon," and remarkably like a dinosaurus. The name may denote *fierce* (or *glittering*) dragon. (This figure is the lower one seen in the picture that appears at the upper left-hand of the double-page of illustrations.)

Dr. Koldewey first visited Babylon in June, 1887, about the time when the present reviewer was working upon the text of the East India House inscription of Nebuchadnezzar (see *Proceedings* of the Society of Biblical Archæology, December, 1887). What a godsend would the present volume have been in those days, clearing up as it does by its thorough investigation of local conditions and the actual remains of the ancient buildings so many of the earlier translators' almost hopeless perplexities! One after another, the Procession Street of Merodach, the Sacred Way along which marched the annual solemnity of Babylon's tutelary god; E-magh, the temple of Nin-magh. "The Exalted Lady," several inscribed cylinders from which may be seen in the British Museum collection; the Gate of Nanâ-Ishtar, with its superb enameled figures; the palace of Nabopolassar (Nabû-apla-uçur), which Nebuchadnezzar restored with great splendor; the location of E-sag-ila, the temple of Merodach, and chief sanctuary of Babylon; the world-famed walls, and various connected structures, were determined and in part exposed to view.

All this, though perhaps not exactly the kind of matter to stimulate the enthusiasm of one who reads merely to while away an idle hour, constitutes a highly important contribution toward an exact topography of Babylon, and to the right understanding of the inscriptions of the Neo-Babylonian period; while it enables classical students to bring to the test of ascertained facts the descriptions of Babylon which we find in Herodotus and subsequent Greek and Latin authors, extracts from whose pages are given in Koldewey's convenient appendix. It is to be hoped that current events in the East may prove no bar to the further prosecution of Dr. Koldewey's meritorious and, indeed, necessary enterprise—even if it happen by the fortune of war that the whole or part of the treasures recovered by his continued labors should find their way to London instead of Berlin.

It should be added that the author has been fortunate in his translator, the English of the book being generally accurate and readable—which is not always the case with translations from German originals.

* By C. J. Ball in *Nature*.

[1] "The Excavations at Babylon." By R. Koldewey. Translated by Agnes S. Johns. Pp. xix + 335. (London: Macmillan and Co., Ltd., 1914.) Price 21s. net.

A Galvanic Cell That Reverses Its Polarity When Illuminated*

IN ordinary cells such as are used to show the alteration of the resistance in selenium under the action of light, the selenium is held between two metallic wires or strips, the light penetrates into the selenium at right angles to the direction of the electric current, and an exterior source of E.M.F. is employed.

The writer has constructed several selenium cells in which the selenium instead of being inclosed between two solids, as mentioned above, was contained between a solid and an electrolyte, when, as the latter was transparent, the light could be caused to pass through the selenium in the same or in the opposite direction to the electric current.

The selenium was spread upon a piece of copper which had previously been tinned to make the selenium more adherent, and then cooked for several hours in the usual manner, the uncovered portions of the copper being varnished with enamel, so that the electrolyte was not in contact with any part of the copper, but only with the selenium. To this end it was found important that there should be no cracks or pores in the selenium coating.

The other electrode consisted of a metal or carbon plate having a hole cut in it the same size as the selenium covering on the first plate, and the two plates were mounted parallel to one another in a coil with a glass window, so that light from the arc in a lantern could be projected through the window and the aperture in the metal or carbon plate on to the selenium surface.

Plain tap water was used as the electrolyte, any acid or alkali being apt to cause the selenium to come away from the copper. As in any case the electrical resistance of the selenium is very great, the extra resistance of the tap water was found of small account. It was found that such cells could be used in the ordinary way to show what is usually called the variation of the resistance of the selenium in light and in darkness with current derived from a separate battery. Some of the cells thus constructed gave good results, though not better than others constructed in the ordinary way.

If the perforated plate was made of zinc, the latter being electro-positive to selenium, the cell then worked as its own battery, the result of light falling on the selenium being to cause a larger flow of current. This might either be because the light caused the selenium to become more electro-negative, or because it reduced the resistance of the selenium. Subsequent tests, in which a Dolezalek quadrant electrometer was used instead of the galvanometer that had previously been employed, showed that the light caused an increase in the E.M.F.

If, however, instead of zinc, carbon or copper was employed for the perforated plate, we had the interesting result that while the selenium proved electro-positive to the carbon or copper in the dark, it immediately became electro-negative to carbon or copper the moment it was illuminated. The reversal of the polarity of a cell of this kind was easily shown on a D'Arsonval moving coil galvanometer of some 285 ohms resistance, large and about equal deflections on two sides of zero being observed in contrary directions when the light was turned on and off. There was rapid polarization in either direction, but this polarization was instantaneously destroyed by reversal of polarity by changing from light to darkness, or vice versa. Measurements were also made with the Dolezalek electrometer, and the E.M.F. proved to be from 0.06 to 0.11 volt in each direction. Tests made with a spectrum showed that the orange and red had the most effect, the violet appearing to have no effect at all. The results differ from those obtained by the late Prof. Minchin with his photo-electric cells of selenium and aluminium in methyl-alcohol and acetone (*Phil. Mag.*, 5-31, pp. 229-234, 1891), inasmuch as these latter gave no current at all unless illuminated. Again, as in the writer's experiments both electrodes had approximately an equal amount of surface illuminated, the results seem to have no connection with those studies by Becquerel, who found that in an electrolytic cell a difference of potential can be obtained when one electrode is in darkness and the other is illuminated. Moreover, the effect with the selenium was found to be hundreds of times more powerful than what can be obtained by merely illuminating one of two similar electrodes and keeping the other in darkness.

The result with the selenium would appear to be consonant with the action of the light being to cause the emission from the selenium into the electrolyte of negative corpuscles. In any case, the results point to the so-called alteration in the resistance of selenium under illumination being in reality due to an E.M.F. being generated.

The writer is much indebted to Mr. A. L. Davis for his skill and patience in constructing the cells and for his assistance in carrying out the investigations.

Prof. T. Mather asked if the increase of current produced by the illumination was proportional to the E.M.F. which the author had detected with the quadrant electrometer.

Mr. S. D. Chalmers asked if heat waves would produce the effect.

Mr. W. Dubbell commented on the fact that the visible rays were most effective while the ultra-violet rays were ineffective, and contrasted the result with the recent discovery that selenium is very sensitive to X-rays.

Mr. D. Owen asked if the action was instantaneous. If so, by using intermittent illumination one should get a strong effect produced in a telephone circuit.

Mr. G. D. West thought that the ineffectiveness of the ultra-violet radiation might be due to the absorption of these rays which was bound to occur in the electrolyte.

In reply to these questions the author said that the extreme instability of the cell made it impossible to coordinate readings of the current and the E.M.F. produced by illumination. He did not think heat waves were able to produce the effort, as passing the light through a solution of alum did not greatly reduce it. The action, he thought, was practically instantaneous. He agreed that the absorption of the cell would probably account for the ineffectiveness of the ultra-violet rays.

* By Alan A. Campbell in *Proceedings* of the Physical Society of London.

Lime Burning

Conditions Necessary for Economical Production

A SHORT theoretical discussion is necessary in order that the conditions required for the economical burning of lime may be comprehended.

There are three factors essential to the process of lime burning: (1) The stone must be heated to the temperature of dissociation of the carbonates; (2) this temperature must be maintained for a certain length of time; (3) the carbon dioxide evolved must be removed.

The physical properties of the stone undoubtedly have some influence on the heat required and on the time in which this heat can be transferred at any given temperature. Thus it will take longer to burn a large piece of stone than a smaller one. A fine-grained dense stone will conduct the heat more readily than one which is coarsely crystalline and porous. The time required to transfer a given amount of heat, roughly speaking, varies inversely with the temperature difference. Therefore it has been found economical to use as high a temperature as possible in order to reduce the time required for burning. The upper limit of the temperature is determined by the phenomenon of "overburning." Overburned lime can be recognized by its yellow color and the extreme length of time it takes to slake. These properties are probably caused by a chemical combination of the lime with the impurities contained in it. That this is the case is indicated by the fact that it has been found practically impossible to overburn some limes which are exceptionally pure. Lime may be overburned by being heated for too long a time as well as at too high a temperature. In general it is better to underburn than to overburn the lime, for the unburned stone may be put back into the kiln, but the overburned lime is useless. Moreover, the properties of overburning seem to assert themselves gradually, so that the best lime is obtained by using the minimum amount of heat.

To summarize: A certain quantity of heat must be supplied to dissociate the carbonates in the stone. The quantity varies with the chemical and physical properties of the stone. In supplying this heat it is optional to use either a high temperature for a short time or a lower temperature for a longer time. The temperature used must be higher than 898 deg. Cent. (1,648 deg. Fahr.) if the decomposition is to take place at atmospheric pressure. The more nearly the amount of heat used approaches the minimum required the better will be the quality of the lime.

It is well known that the chemical reaction involved in burning lime is reversible. That is, calcium carbonate may be decomposed into calcium oxide and carbon dioxide, or these substances may recombine to form calcium carbonate. The factor which determines the way the reaction shall go is the pressure of the carbon dioxide.[1] If the gas is removed as formed so that its partial pressure is kept below that given for the temperature by Johnston's equation, the reaction will continue in the direction to form lime. But if the gas is allowed to accumulate until its pressure becomes higher than this, the reaction will be reversed and will give rise to the phenomenon known technically as "recarbonating." Therefore the prompt removal of the gas is an essential operation in lime burning.

Wood has long been recognized as the best fuel with which to burn lime and is used wherever it can be obtained with any degree of economy. The number of such localities is rapidly growing smaller, so that the problem of using some other fuel is of increasing importance. Experience has shown that wood gives a larger capacity and a better quality of lime, and requires less care in the operation of the kiln than coal. Therefore the tendency of experiments with the latter fuel has been to modify the normal coal fire so that it will to some extent resemble the combustion of wood. A wood fire has three characteristics which distinguish it from a coal fire in its adaptability to lime burning: (1) Its flame is longer. This enables the heat to penetrate farther toward the center of the shaft and creates a larger burning zone. Therefore the capacity of the kiln is greater and the lime tends to burn more evenly, causing less difficulty in the operation. (2) The amount of water generated by burning wood is much greater than that from coal. The pressure of this steam in the products of combustion lowers the temperature required for calcination[2] and thus lengthens the burning zone and increases the capacity of the kiln. (3) The flame from a wood fire is cooler than the flame from coal. This, in connection with the effect of the presence of steam, results in less danger of overburning and a better quality of product.

In all kilns where wood is burned, natural draught has been found satisfactory.

The easiest way of modifying a coal fire so as to cause it to resemble the combustion of wood is to use a mixture of wood and coal. This works successfully wherever tried, but even the small amount of wood needed is not economically obtainable in many localities.

Many lime manufacturers are, therefore, forced, much against their will, to use coal for their fuel supply. The reasons cited above show why the coal fire should be modified to resemble the wood fire, and it may also be added that in many kilns the normal combustion of coal has proved distinctly unsatisfactory for the burning of lime. Experiments on modifying the fire have been mostly confined to different methods of producing the draught.

The following methods for producing draughts are in general use: Natural draught; forced draught, caused by blowing steam under the grates; induced draught, created by a fan which draws the gas from the top of the kiln; and the Eldred process, according to which a fan takes the gas from the top of the kiln and forces as much of it as is required back under the grates. In order to determine the relative efficiencies of these processes a number of heat balances were made.

From the results so obtained, the following general conclusions can be drawn: If the lime is drawn hot, or if it is left in the cooler until cold, the heat which it contains will be lost. This heat can be saved and used to preheat the air required for combustion, if this air is taken in through the shears in direct contact with the lime, or through ducts built in the walls of the cooler.

The heat contained in the escaping stack gases can be recovered in part by introducing some of the gas under the grates, as in the Eldred process. The recovery may be more nearly complete if the gases are passed through a boiler or feed-water heater, and their heat used to generate power. If natural draught is relied upon the heat of the gas must be considered as being used to create the draught. It was found, however, that natural draught requires a great deal more heat than any kind of artificial draught. The use of the heat of the gas for this purpose is not to be recommended, therefore, and it would probably be found more economical to build the kiln sufficiently high, so that the heat of the gas would all be taken up by the stone, and to rely upon a fan to furnish the draught.

With good capacity and careful firing the loss of heat due to combustible material in the ash should be very small; by the use of a good gas producer, it should be reduced to a minimum.

The heat lost by radiation and conduction may be considered as emanating from three parts of the kiln—the gas main or fire box, the bottom of the kiln, where the lime is permitted to cool after being burned, and the shaft of the kiln. A study of the designs of the various kilns show that the following methods should tend to reduce the amount of heat lost in this manner. The gas main leading from the producer to the kiln should be short or should be insulated. The comparatively poor gas which it is necessary to use for burning lime carries a large part of its energy as sensible heat, and the loss of this heat can be prevented only by introducing the gas into the kiln at the same temperature at which it leaves the producer. Fire boxes will show less loss by radiation when built within the shell of the kiln, rather than externally. A large part of the heat contained in the lime after it is burned will be lost by radiation before the lime is drawn out of the kiln unless means are supplied by which this heat can be recovered and used. Unless the kiln wall is extraordinarily thin or the temperature used extraordinarily high, the loss by radiation from the shaft of the kiln seems to be very small. This can be still further reduced by increasing the diameter of the kiln.

In conclusion, it must be emphasized that the heat efficiency is only one item of the total plant economy. The cost of labor, the ratio of capacity to investment, and the quality of the product must also be considered. Therefore, merely because the figures show a plant to have a high heat efficiency would be no reason for stating that it is the most economical plant.

In the light of the facts brought out by investigation a theoretical discussion of the different methods of producing the draught may not be out of place.

Natural draught, by the use of stacks, can be made sufficient to give good capacity. However, there is grave danger of overburning most stone, for with strong draught the flame may be short and hot. Conditions may easily arise which will force the products of combustion down into the cooler, thus causing recarbonation. Since there is no means of controlling the pressure of gas over the fire, every time the fire door is opened cold air rushes in, which may cause a loss of heat and increase the cost of repairs.

The practice of blowing steam under the grates is obviously one method of introducing the moisture obtained by burning wood. But water content does more than lower the calcination temperature. Part of it is undoubtedly dissociated into its elements while passing through the hot fire. This dissociation takes up heat, which is later given out in the kiln where the elements recombine. Consequently the use of steam tends to cool the fire and produce a longer flame, both highly desirable objects to lime burners. On account of the cooler fire and lower calcination temperature, the capacity of the kiln may be increased with less danger of overburning than when natural draught is used. The forced draught under the grates permits of regulating the pressure above the fire, and therefore the fire door may be opened without admitting enough air to influence the efficiency of repair cost of the kiln. Forced draught does not, however, prevent the production of combustion from going down into the cooler.

This danger of recarbonating the lime can be eliminated by the use of induced draught. When used alone, however, the characteristics of the fire produced by this type of draught have all the disadvantages of a normal coal fire. Since induced draught is created by a fan, any heat carried off by the waste gases is a total loss.

In many kilns a combination of forced and induced draught is used with very good results. The induced draught prevents recarbonation of the lime by removing the carbon dioxide as fast as formed. The forced draught by means of the steam jet gives a cooler fire and a longer flame and also permits control of the gas pressure over the fire. Owing to the lower calcination temperature and the greater rapidity of combustion attainable, this method should give the maximum kiln capacity.

Another method of combining the forced and induced draught is according to the Eldred process. For maximum economy the top of the kiln should be closed air tight, and all the gas should be removed by the fan, as in creating induced draught. This fan should deliver as much gas as needed under the grates and should blow the remainder out through a stack. Separate and fairly accurate means of controlling the supply of both air and gas should be provided, and the induced draught created by the fan should be entirely independent of the amount of gas used for the forced draught. As thus installed, many advantages of the combined forced and induced draught may be obtained by using the Eldred process. The induced draught tends to prevent recarbonation and the forced draught permits regulation of the gas pressure over the fire. The fire is kept cool by diluting the air with carbon dioxide taken from the kiln, thus causing a slower rate of combustion. The introduction of an excess of carbon dioxide might be expected to cause recarbonation of the lime, but experience has shown that it does not—probably because the temperature is sufficiently high to prevent the combination. This carbon dioxide also aids by mechanically carrying heat from the fire into the kiln. Moreover, it may act chemically to some extent, since some of it may be reduced to carbon monoxide while passing through the hot fire. This reduction absorbs heat from the fire and liberates it again when the carbon monoxide burns in the kiln in a manner similar to the action of steam. Carbon dioxide does not serve the same purpose as steam, however, for it does not lower the temperature of calcination.

In comparing the two methods—steam and induced draught versus the Eldred process—it must be noted that they both produce a cool fire by mechanically and chemically transferring the heat from the fire box into the kiln. The former methods gives a high rate of combustion and a lower calcination temperature, both of which tend to increase the capacity. Owing to lack of oxygen, the Eldred process causes the coal to burn more slowly. This would tend to give a lower output.

In general it may be said that the best method to be used for creating the draught depends on local conditions, chiefly the kind of stone. Thus, if the stone is difficult to overburn, a high output and good quality of lime may be obtained with natural draught. If there is danger of overburning, the forced and induced draught will probably give good results. If there is great danger of overburning or if the lime is apt to act as a flux on the lining, the Eldred process may be used to obtain a good quality of product and keep the repair cost within reasonable limits.—*Mineral Resources of the U. S., 1913, Part II, U. S. Geological Survey.*

It is Stated That a Paper Mill in Ohio is saving $400 a week by substituting electricity for steam. Each machine has its individual drive, and this saves the power formerly required for the long lines of shafting. Several men are also dispensed with.

[1] Bleininger, A. V., Am. Ceramic Soc. Trans., vol. 9, p. 454, 1907.
[2] Peppel, S. V., Ohio Geol. Survey Bull. 4, p. 294, 1906.

The Construction of a Multiple Tuner

Complete Working Drawings and Specifications for the Amateur

By C. L. Sears

MANY articles have been written on the Multiple Tuner but the writer has not seen any which gives details enabling the amateur to build his own set. They have described the working or manipulation of the set, but have not given the size or shape of the coils, or their winding dimensions and wire sizes. Here is a set which is somewhat modified and has not the complications of the commercial sets. These instructions were not taken from any professional source, but were evolved by the author after having obtained the wiring diagram.

First we shall figure on the case.

Well seasoned cherry, walnut or mahogany, ½ inch thick should be used. We shall need (see Fig. 1):

2 pieces ½ x 13 x 15 inches (A)
2 pieces ½ x 5 x 12 inches (B)
2 pieces ½ x 5 x 15 inches (C)

These dimensions allow for mitered corners, as shown at *A*. If square joints are to be used the pieces *B* can be made 1 inch shorter or ½ x 5 x 11 inches. The box should be glued and assembled with finishing nails about 1¼ or 1½ inches long. The bottom should be put on with a dozen 1 inch No. 10 wood screws, flat head iron, to allow for inspection of the interior. After the box is assembled the nail heads should be set below the surface with a nail set and the holes filled with bees-wax. The case should be well sandpapered and given four coats of varnish put on very thin, sandpapering lightly after each coat. The coats of varnish should be put on at least 24 hours apart and kept in a warm dry place while drying. The inside of the box also should be given one coat, although it need not be sandpapered as it is only used to improve the insulating properties of the wood.

For polishing the box about five cents worth of finely powdered pumice and the same amount of rotten stone will be needed, also a small block of wood about 3-inches square and 7/8 inch thick. The block should have four or five thicknesses of old muslin tacked on it. The tacks should not be placed on the face but on the edges.

Place some of the pumice on a piece of heavy paper and also have a shallow pan of water handy. Then dipping the block into the water and into the pumice go evenly over the entire surface of the box with a scouring motion in the same direction always. Rub the varnish down in this manner, keeping the block well moistened and dipping in the pumice as needed until the box is very smooth. It will take about an hour or so to do all the surfaces. Then clean off all the remaining pumice stone and water with a damp cloth and wipe dry. Now take the rotten stone and, using oil instead of water, proceed as before, until a finish similar to a piano finish is obtained. A finished box like this can be purchased for about three or four dollars, but more satisfaction is to be had if box and all are made from the rough materials.

In Figs. 2 and 3 are shown the forms of the primary, intermediate and secondary coils. These will require the use of a lathe. For Fig. 2 fiber tubing 4¾ inches in diameter and 1/8 inch thick is required. This can be made by glueing 1/32 inch fiber in four layers around a wooden form.

After the tubes have set hard they should be given a coat of glue and be wound with a single layer of No. 22 double cotton-covered copper wire 1¼ inches wide or 35 turns split ¼ inch apart at the center as shown in Fig. 2. Two binding posts made of 3/8 inch, 6-32 brass machine screws, with two small hex nuts on it, should be mounted about 3/16 inch from each side of the tube and the ends of the wire soldered to them. This completes the two primaries. One primary should have its winding covered with another piece of 1/32 inch fiber and a layer of No. 32 single silk-covered copper wire should be wound on it, split ¼ inch at the center also, and have a winding of 186 turns, 93 on each side of the center, with 6 taps taken off. The taps and the starting point or lead should be fastened to 7 binding posts on the edge, as in the primary coil. This completes the secondary. Then the wooden forms for the intermediate coils should be turned out; they should be made of ash. Four small quad-style binding posts should be mounted inside the forms, two on each coil. These coils have a semi-spherical form to allow for closer coupling between the circuits. When the forms are completed they should be given a light coat of glue and a single layer of No. 26 S.S.C. wound on each side of the center. Wind from edge inward 59 turns or a total of 118 turns on each coil. The two ends in the center should be soldered together and the outer ends each fastened to a binding post making a single split layer. The wire must all be wound in the same direction around the form. It is a good plan to varnish both the two primary tubes and the intermediate forms although no varnish should be put over the wire. The tubes and forms should then have a 3/16-inch or slightly larger hole drilled through them as shown in the illustrations Figs. 2 and 3.

Next we must consider a loading coil. This will require two flanged discs of ash turned to the dimensions given in Fig. 4. A cardboard tube this size can either be made by rolling a piece of cardboard around a wooden form or a very serviceable tube can be made from a paper carton or box. A small quad binding post should be mounted in one of the turned wooden ends and the other wooden end should be drilled as shown at *A* with 13 holes set in a curve as shown for the leads or taps to come through. Then the wooden end holding the binding post should be fastened in the tube and after the tube has had a light coat of glue over its entire surface, 14 holes should be punched in a spiral around the tube from within ½ inch of one end to within ½ inch of the other. The first six from the binding post end should be spaced about ¼ inch apart and the remainder about 9/16 inch apart. Then the wire, No. 22 D.C.C., should be put on, the end being soldered to the binding post. Instead of soldering pieces of wire on the coil to make taps when coming to a hole in the tube, simply loop the wire for about 15 inches, push it through the hole in the tube and draw it tight; this will save the soldering of 12 joints and will also make a neater appearance. When all the taps or leads have been put through the tube they should be run in proper order through the holes made in the wooden end and the end fastened to the tube. This completes our loading coil except for varnishing the two ends, not the wire.

In Fig. 5 we have a sketch of the fixed condenser which has a capacity when rolled of about 0.002 microfarad. The greatest fault with most commercial fixed condensers is that their capacity is approximately 0.015 or 0.01 microfarad, which is about five times too large, giving a poor tone to the incoming signals. This condenser will require three pieces of good quality note paper 1¼ x 8½ inches, and two pieces of medium weight tinfoil or, better, copper foil, 7/8 x 8½ inches. This paper should have no holes, print or ink nor bits of foreign matter in it. Each piece of tinfoil should be placed on a piece of the paper while still hot, after paraffining all three sheets. Then after arranging the pieces of paper evenly and flat on top of each other, place the tinfoil end as shown, solder a short piece of drop-cord to each terminal, roll the whole thing around a small piece of wood about ½ inch in diameter, and tie firmly with a piece of light string. This will result in one connection being on the

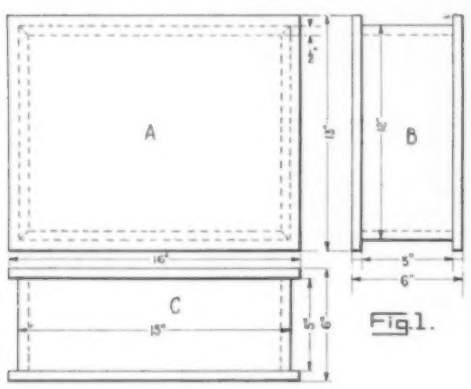


Fig. 1.

Fig. 2. 2 Required

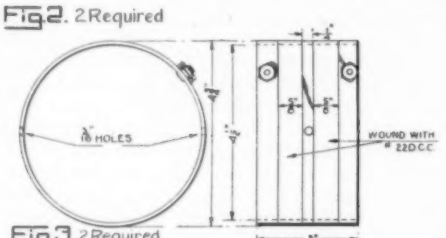


Fig. 3. 2 Required

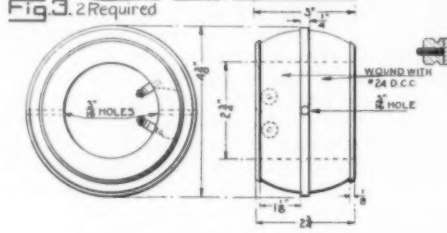
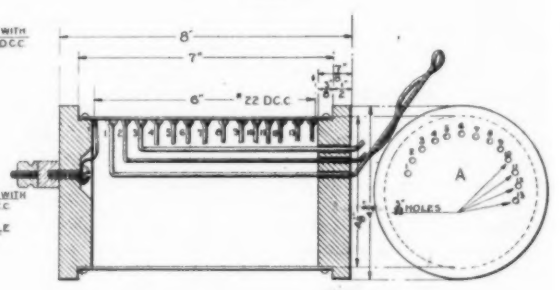


Fig. 4.



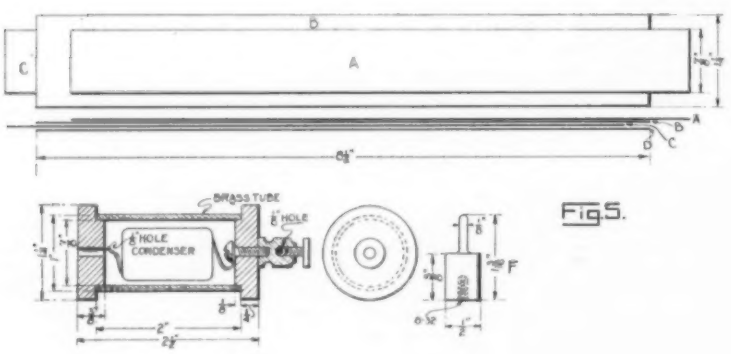


Fig. 5.

Fig. 6.

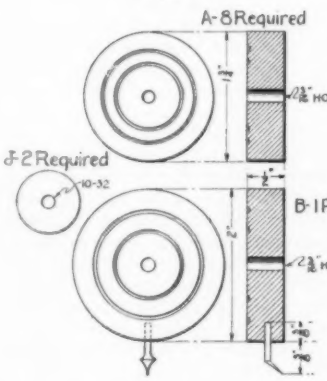
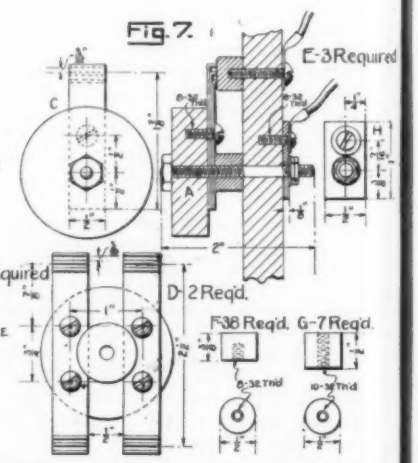


Fig. 7.



inside and the other on the outside. Then remove the piece of wood, roll the condenser in some paraffine and let it cool. Solder each small piece of wire to a ½ inch 8-32 brass machine screw.

To make the case for the condenser we shall need a 2 inch length of 1 inch brass tube having a 1/16 inch wall, two small binding posts like the one shown, and also two pieces of 3/8 inch black fiber 1¼ inch diameter with a 7/8 inch flange for the ends. In assembling the condenser care should be taken that the ends do not touch the inner wall of the tube. At *F*, Fig. 5, is shown a small holder turned from ½ inch round brass rod, with a tapped hole in the base.

Next we must consider our switches. We shall need 38 switch points as shown at *F* Fig. 7, tapped 8/32 to a depth of 5/16 inch, and 7 bearings for handles, as shown at *G*. The switch points and bearings are made from ½ inch round rod. The switch arms or levers are made from 1/32 by ½ inch brass tape or strips. It will require 49 inches, cut as follows:

3 pieces 2 3/32 inches, one end bent over 3/32 inch.
3 pieces 1 15/16 inches, one end bent over 1/16 inch.
3 pieces 1 25/32 inches, one end bent over 1/32 inch.
For three single arm switches.
4 pieces 2 3/8 inches, both ends bent over 1/32 inch.

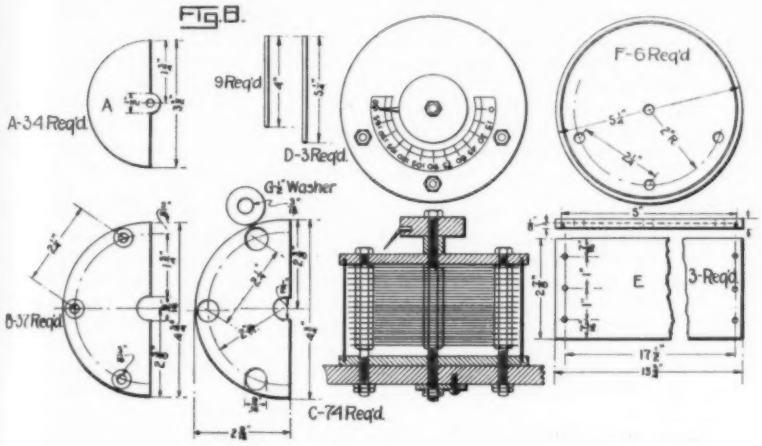


Fig. 8.

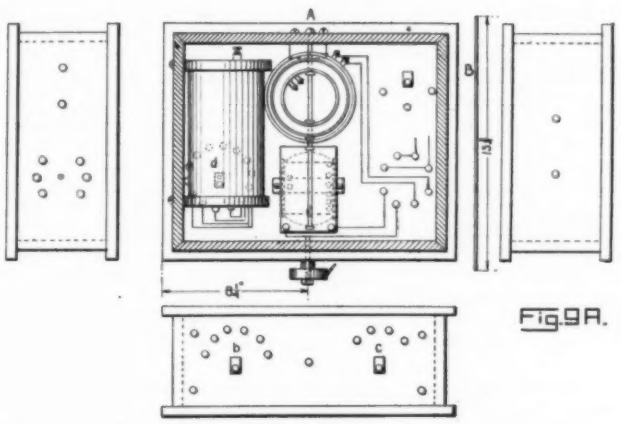


Fig. 9A.

4 pieces 2 9/16 inches, both ends bent over 1/16 inch.
4 pieces 3 1/8 inches, both ends bent over 3/32 inch.
For two double arms switches.

The pieces for the single arm switches should be drilled as shown in views *C* and *E*, Fig. 7; those for the double arm switches as in *D*. The switch handles are turned from ½ inch black sheet fiber as at *A* and *B*, in Fig. 6.

Bearings for double arm switches (see *J*, Fig. 6) are 7/8 inch in diameter, threaded through 10-32, and ½ inch thick. The handles may be knurled on the edges. Three of the 1¾ inch handles and the one 2 inch handle should have pointers set in them as shown in *B*, Fig. 6. Bore a hole about 3/8 inch deep into each handle, big enough to barely admit a piece of No. 12 aluminum wire, then flatten the tip of the wire and cut to a point. These handles will serve for the three variable condensers and the coupling handle for turning the intermediate coils. Three of the other 1¾ inch handles should be used in assembling the three single arm switches (shown in *E*, Fig. 7), and two should be used for the two double arm switches. The brass switch arms should be mounted on the bottom of the handles by means of 3/8 inch 8-32 brass screws (see sketches *D* and *E*, Fig. 7).

The variable condensers shown in Fig. 8 will require 37 pieces of 1/32 inch copper, 4¾ inches in diameter, for the electrodes. The best and the easiest way to do this is to cut out 37 circles 4¾ inches in diameter and then after making a form from a piece of tin each circle will make one fixed (*B*) and one movable (*A*) electrode. When cut out the electrodes should be drilled as shown (3/16 inch holes). The pieces shown by *C* are cut from 1/64 inch red sheet fiber. They are slightly greater than semicircles and should have a tin form made for them. The holes in the fiber are spaced exactly as in *B*, except that they are 9/16 inch holes instead of 3/16 inch. The six pieces (*F*) of black ¼ inch sheet fiber which are required for the tops and bottoms of the condenser also have 3/16 inch holes bored in them as in *B*. These pieces have a groove 1/8 inch deep and 3/64 inch wide cut in them on a diameter of 5 inches. The pieces shown at *E* are made of 1/32 inch brass, bent into a cylinder and riveted with small rivets. They form the sides of the three condenser cases.

The variable condensers 9 and 7 (Fig. 10) have 14 movable and 15 fixed plates. Condenser 11 has 6 movable and 7 fixed plates. In assembling the condenser a space of two washers (*G*) is used between each two plates, or six washers to separate the stationary plates and two to separate the movable or rotary plates, also pieces of fiber like *C* should be placed between each pair of fixed plates as insulation instead of air. A piece of ½ x 1/8 inch brass, such as used on the switch arm (see *H*, Fig. 7) should be used for each variable under the shaft for the rotary plates for connections for the handles and bearings (see *A*, Fig. 6 and *G*, Fig. 7). The assembling of the three variables will not be explained; for the only differences between the kind given here and others, lies in the use of fiber insulators between the plates and the cases and this subject has been gone over a great deal heretofore. The plates are clamped top and bottom and held to the cases by 10/32 brass hexagonal nuts, although a better appearance would be had if small acorn nuts were used on top of the cases. The dials for the condensers are made from celluloid, the lines being scratched in, and black oil paint being rubbed in to make them show up.

Assuming that all our instruments are finished, the exposed brass work should be buffed. If the case is of walnut the brass work should be buffed and lacquered; if of cherry or mahogany the brass work should be nickel plated. After the brass work is completed the instruments should be assembled on the case (see Fig. 9). Single arm switches 4-11-14 have their contacts set in a circle around the center hole of 1 3/8 inch radius. Double arm (D.P.D.T.) switches 3 and 8 are mounted circles of 1 5/16 inch radius. For mounting the switches see sketches *E* and *D*, Fig. 7. The pieces marked *H* are used under the rotary members of the variables and the single arm switches, so that flexible wires need not be used.

In Fig. 9 *1* and *2* are aerial and ground posts; *3* is a switch for placing condenser (*5*) in series or parallel with the primary circuit; *4* is the switch for the loading coil (14 points); *5* is the ground condenser (15 and 14 plates); *6*, the variable (of 15 and 14 plates) connected across the leads of the intermediate coils which are in series; *7*, secondary variable (7 and 6 plates) shunted across the secondary coil; *8*, switch for throwing in either the tuning primary (*5* in Fig. 10) or the standby primary (*6*, Fig. 10); *9*, celluloid scale reading 0 to 90 degrees for pointer on coupling handle *12*; *10*, binding posts for phones; *11*, selective switch to use any one of three detectors or short circuit the phones when sending; *12*, coupling handle to rotate intermediate coils inside of primary and secondary tubes; *13*, switch to vary turns on the secondary; *14*, binding posts for extra detector, for testing, or for an audion detector; *15*, fixed condenser; and *16* and *17* are detectors.

In Fig. 9, *A*, is seen the interior arrangement of the box. The intermediate coils are placed inside the tubes, which should be set at right angles to each other, as shown, and mounted on a piece of 10/32 threaded brass rod, being clamped tightly by means of four 10/32 hexagonal nuts to each intermediate coil.

The tubes may be held in place by slotted pieces of wood, which should be set so that the coils can rotate through 90 degrees easily. The loading can be held in place by two No. 10 brass wood screws about 1 inch long.

All wiring should be done with drop cord. The loading coil taps should all be carefully fastened to the switch contacts and firmly soldered.

Fig. 9.

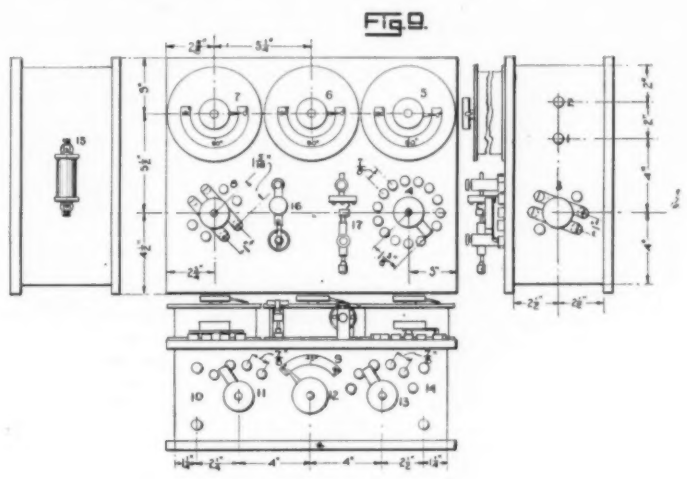
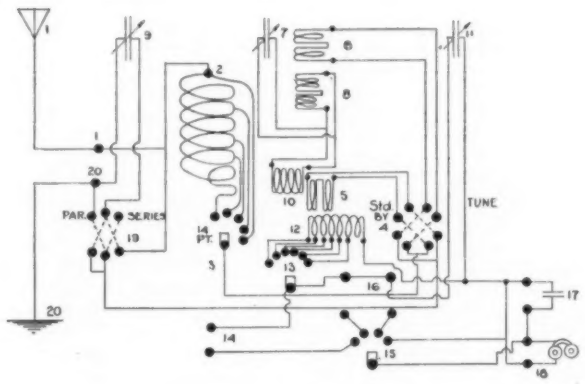


Fig. 10.



In Fig. 10 the instruments in the wiring diagram are in their approximate places looking at the inside of the box with the front toward the observer. The parts are referred to by number as follows:

1, binding post for aerial connection; *2*, loading coil whose taps are connected to 13 points of the 14-point switch—the remaining point *3* shorts the loading coil; *3*, loading coil switch; *4*, rotary switch useing a D.P.D.L. switch to throw in either "tuning" primary or "standby" primary *6*; *7*, is the variable connected across the two leads, exactly in the center, which connects the intermediate coils *8* and *10* in series; *9*, is the variable used in the primary circuit; *11*, is the secondary variable connected across the secondary leads; *12*, is the secondary coil of No. 32 S.S.C. whose six taps are led to switch *13*; *14*, are the posts for the extra detector; *15*, is the selective switch for either short circuiting the phones, when sending, or selecting any of the three detectors at *16* or *14*; *17*, is the small fixed condenser connected across the phones; and *18*, posts for phones. If an audion is used instead of connecting the phones direct to the posts *18* they should be connected to the center posts of a small D.P.D.L. knife switch whose one side leads to posts *18*, and the other to the audion box phone posts.

The manipulation of these sets is familiar to many amateurs, but for the benefit of those who are not, a brief description will be given:

Connect up the ground and air either to an antenna switch or to the opposite sides of an anchor gap which is in series with an aerial oscillation transformer and

ground connection. Instead of the anchor gap, which entails a loss in transmitting, a S.T.D.P. knife switch may be used, one side being used instead of an anchor gap and the other to control the primary current of the transformer. When the switch is up one can receive, but cannot send; when down the transmitter can be operated, as the receiving set is then short circuited.

When listening in the switch *8*, Fig. 9, should be set at standby position until a station is heard; then throw the switch to the tuning position and tune by adjusting the various condensers and secondary taps. The coupling of the intermediate circuit with the tuning primary and secondary circuits if loosened (by moving the pointer on scale of coupling handle between 0 degrees and 90 degrees) tends to lower the wave length of the circuit and it can be raised again by putting in more capacity by means of the intermediate variable condenser. The looser the coupling (the nearer to 90 degrees) the sharper the tuning. The switch *3*, Fig. 9, should normally be thrown so that the primary variable condenser is in series with the primary coils, except on very long wave lengths, when it should be thrown to the parallel connection position. A little practice will enable one quickly to set the capacities and coils in the correct relation to one another. If static is bad a high resistance coil of some sort wound on a porcelain or other non-metallic core to a resistance of about 10,000 ohms and connected directly across posts *1* and *2*, Fig. 9, will tend to destroy its effect when receiving. This set, for satisfactory long distance work, should be used with an aerial at least 30 feet above ground and 50 feet long, consisting of 4 wires, spaced 4 feet apart and connected in an inverted "L," so as to get as great a natural period or wave length as possible for an aerial of given size.

The telephones to be used with this set should preferably have a resistance of 3,000 to 3,200 ohms. If possible an audion should be used as it gives little or no trouble in comparison with crystal detectors, and is about three times as sensitive. A set like the one described will have a probable range on winter nights, especially, of about 1,800 to 2,000 miles with an aerial 50 feet high and 75 feet long.

The Medicine of the Old Testament—I*

Primitive Remedies, Practice and Superstitions of Acient Palestine

By Stuart B. Blakely, M.D.

In a study of the medicine of the Old Testament two points must be kept always clearly in mind: (1) It is a study of the non-medical literature of a primitive, nomad race. (2) References to disease and medical subjects are dark and incomplete. Careful study of the original Hebrew words themselves has been of little service. Most of the diseases described are either those of kings or personages of high estate or epidemics. If we realize that little is absolutely sure, that much must be inferred, and if we recognize the difficulties of the problems we shall not be led far astray in the medical survey of the Old Testament.

The scriptural references given in this article by no means exhaust the possibilities of the text.

The medicine of the ancient Hebrews was partly of Egyptian, partly of Assyrian and Babylonian origin with, in later times, a possible trace of Greek influence. The medicine of Egypt was famous in its time throughout the East. Cyrus and Darius both summoned physicians from that country. Many of the physicians at the courts of the kings of Israel were probably Egyptian. The learning and culture of Assyria and Babylonia reached flood mark. The ancient Hebrews acquired their medicine during the sojourn in Egypt, by intercourse with other nations, especially during the reign of Solomon, and during the captivities. But the Hebrews were never scientists. They had no scientific institutions. Their science and their medicine were borrowed and empirical. To their minds Jehovah was the highest authority in all things. Jehovah was the Supreme Healer. (Ex. 15, 26; Dt. 32, 39; Ps. 6, 2; 30, 2; 103, 3; Is. 30, 26.) Injury, disease and death were usually regarded as expressions of his wrath, as direct results of his omnipotent will. As a consequence of this belief we find little or nothing in the Old Testament concerning the cause, the course, or the curing of disease. Disease was often looked upon as a direct punishment for sin, a belief prevalent among primitive folk. Threats of disease for sin and disobedience and promises of protection against disease are very common. (Ex. 15, 26; Nu. 14, 12; Dt. 7, 15; 28, 59–62; 32, 39; II Sa. 24, 16; II K. 19, 35; II Ch. 21, 14; Job 2, 5–7; Is. 58, 8.)

Among most early peoples medicine has been at first the property of the priesthood alone. Among the Hebrews, however, the medical work of the priests seems to have been that of a sanitary police—observing, isolating, and disinfecting. Their duties seem to have been always distinct from those of the physicians. (Gn. 50, 2; Ex. 21, 19; II K. 8, 29; II Ch. 16, 12; Job 13, 4; Jer. 8, 22.) The physicians gathered and prepared their materia medica, prescribed for symptoms of disease and treated wounds. The word "physician" in Jer. 8, 22, is literally "a bandager." There are two references to definite consultations with physicians—Asa to be cured of the disease of his feet and Joram to be healed of his wounds. (II Ch. 16, 12; II K. 8 and 9.) The profession was not so highly nor so strictly specialized as among the Egyptians—*cf.* the corps of physicians in the service of Joseph. (Gn. 50, 2.) It was usually held in high esteem, but Asa was reproached because "in his disease he sought not to the Lord but to the physicians." The author of the apocryphal book of Ecclesiasticus is thought to have been a physician. The prophets Abijah, Elijah, Elisha and Isaiah, by virtue of what we call their miracles, may be classed among the healers of the Hebrews. Midwives followed their calling as they do to-day. (Ex. 1, 15-21.) Their duties were of the simplest. They received the baby, cut and tied the cord, washed the child, rubbed it with salt and wrapped it in swaddling clothes. (Ezk. 16, 4.) It has been suggested that the two mentioned by name in Ex. 1, 15, were the heads of corporations or societies of midwives. Such a thing as a hospital was unknown; the sick, except the lepers and probably the "unclean, were cared for in their homes. (Lv. 13, 46; Nu. 5, 2; II Ch. 26, 21.) The dead were burned, buried or placed in sepulchres. The Hebrews did not embalm. Their mind had no sympathy with the Egyptian idea that originated the custom. Jacob and Joseph were embalmed only to preserve their bodies until burial could take place. Among the Egyptians the art of embalming formed a special branch of medicine. The process varied not only according to the wealth and rank of the deceased, but also at different times in Egyptian history.

It might be interesting to glance briefly at the ancient Hebrews' ideas of anatomy. It is possible that dissection of the human body for scientific purposes had already been done at that early date, but in any knowledge thus obtained the Jewish slaves could have had no share. The Hebrews had no medical schools, no system of medical education. What little true anatomical knowledge they possessed of the internal organs was derived from injuries, war, and the slaughter of animals. All else was tradition or speculation. There are references to the heart, the liver, and the bile or gall, the diaphragm—"the caul above the liver" (Ex. 29, 13), the kidneys, the intestines and the internal fat, and the womb or matrix. The liver was evidently of value in divination. (Ezk. 21, 21.) Certain verses of Proverbs and Ecclesiastes have been cited as proof of Solomon's knowledge of anatomy and the healing art. Traces of a rude conception of embryology are found. (Job 10, 10; Ps. 139, 13–16; Eccl. 11, 5.) Blood to them was life, therefore sacred, and together with the internal fat must be returned to God before the flesh was eaten. (Gn. 9, 4; Lv. 7, 23–27; 17, 10–14; 19, 26; Dt. 12, 23.) They knew that dreams originated from inside the head. (Dan. 4, 5, 13; 7, 1.) The liver was the source of happiness; in several places in the Psalms it is called the "glory." (Ps. 16, 9; 30, 12; 57, 8; 108, 1.) The navel was the seat of health, the heart, the source of emotion and of mental and moral activity, the reins or kidneys the seat of desire and determination, the bowels the place of affection and sympathy. We still preserve many of these ideas as figures of speech, but the Hebrews believed them to be truths. The books of Job, Proverbs, and Ecclesiastes contain a curious store of medical lore.

Palestine was probably healthier than Egypt. In the latter country the valley of the Nile was flooded every year, creating conditions favorable for the development of disease. The plagues of the Egyptians were closely associated with the rising of the Nile and with other well-known climatic conditions of the country. Palestine, on the other hand, was isolated by land and sea. Communication with it was difficult. Disease was not apt to be carried to it. The land was dry and sanitation was good. There was no overcrowding and no poverty. Under the leadership of Moses, a priest from the temple of the Sun at Heliopolis, the Hebrews became the founders of public hygiene. In Leviticus and Deuteronomy are very definite rules and regulations regarding food, clean and unclean things, sexual hygiene, personal purifications, and contagious diseases. In Ex. 21, 22 and Lv. 24, are found traces of a medical jurisprudence.

We cannot enter into a discussion of the sanitary code of the Hebrews; neither will we describe practices that became religious rites, e. g. circumcision. We can only speak briefly of the drugs and methods used in treatment and call attention to some of the diseases and diseased conditions mentioned in the Old Testament text.

The ancient Hebrews had many medicines. (Jer. 46, 11.) We hear of no specifics. The following were some of their therapeutic agents: leaves of trees (Ezk. 47, 12), olive oil, balm of Gilead, a famous resinous application for pain and wounds, and a valuable article of commerce, fig plasters, oil and wine for wounds. The mandrake root was used for barrenness, following the old doctrine of signatures. (Gn. 30, 14–17.) The word translated "gourd" in the last chapter of Jonah is thought by some to mean the castor-oil plant. The personal and ceremonial use of ointments, perfumes, and incense was common, as among all Orientals. These were prepared by the apothecaries and confectioners. (Ex. 30, 25; 37, 29; Isa. 8, 13; II Ch. 16, 4; Neh. 3, 8; Eccl. 10, 1.) The ingredients were both domestic and imported, and their list is long. Among them were frankincense, myrrh, aloes, calamus, camphire or henna, cassia, cinnamon, galbanum, rue, spicery, saffron, storax and others. The following were more strictly medical in their use, as condiments or carminitives—cassia, cinnamon, coriander, cummin, salt, and probably also anise, mint and mustard. The prescription for the holy anointing oil is given in Ex., 30. Salt was used to harden the skin, niter and soap to cleanse it. (Jer. 2, 22.) The niter was natron, a mineral alkali; the soap was probably potassium carbonate mixed with oil. Elisha used salt to purify springs of water that were reputed to cause miscarriage and death. (II K. 2, 19-22.) Hyssop seems to have been a substance whose use approached that of an antiseptic. It was probably either the marjoram, or the caper plant. The Psalmist lauds its "purging" powers; it was sprinkled on the doorposts of the Israelites in Egypt and was employed to purify lepers and leprous houses. (Ps. 51, 7; Ex. 12, 22; Lv. 14, 4–7, 49–52.) Mankind still clings tenaciously to the belief that the smoke or vapor from burning incense or other odoriferous substances possess detergent properties. It is possible that Hazael practised hydrotherapy when he dipped a cloth in water and spread it on the face of Benhadad, King of Syria, though it sounds more like murder. (II K. 8, 15.) Mineral and oil baths were sometimes employed. The pool of Siloam possessed healing powers. (Neh. 3, 15; Is. 8, 6.) Hot springs—"mules" are mentioned in Gn. 36, 24. These were probably near the Dead Sea. The water of the Jordan contained sulphur, and was famous for its curative properties, *cf.*, Naaman's leprosy. The wearing of amulets, the use of charms and invocations and the laying on of hands in the presence of disease were common practices then as they are to-day. (II K. 5, 11.) The influence of the state of mind on sickness was clearly recognized—"a merry heart doeth good like a medicine." (Pr. 17, 22.) Some kind of arrow poison was possibly in use, most probably aconite. (Job 6, 4.) The water of gall, or the "water of the poisonous plant," may refer to the poppy. (Jer. 9, 15; 23, 15.) Food poisoning of vegetable origin—possibly colocynth or the bitter cucumber—is mentioned in II K. 4, 38–41, for which Elisah used meal as an antidote. Ptomain or meat poisoning was probably the plague that followed the eating of the quail. (Nu. 11, 31–33.) The Hebrews knew well the action of alcoholic drink. They made wine from honey, dates, grapes and other fruits, and it was sometimes spiced. Certain localities were famed for their product of the vine. The drunkard has been inimitably portrayed in Pr. 23.

As among the Egyptians many remedies were dietary. The ancient Hebrews had an ample and excellent variety of food: meat, fish, fowl, game, locusts, eggs, butter, milk, cheese, sour milk, meal of various grains, bread, beans, cucumbers, onions, garlic, lentils, herbs, manna, honey, fruits, melons, figs, raisins, grapes, nuts, olive oil, vinegar or sour wine, salt, and condiments. The ancient Hebrews probably had no sugar; honey, manna, and fruit juice decoctions were substitutes. The "sweet cane" of Is. 43, 24, and Jer. 6, 20, was probably the sweet flag or calamus. There is evidence of cannabalism taking place in Old Testament times under stress of circumstances. (Lv. 26, 29; Dt. 28, 53; Jer. 19, 9; Ezk. 5, 10.)

The surgical lore of the Old Testament is very scanty.

*Read before the Men's Forum of the First Congregational Church, at Binghamton, N. Y.

Knives of flint or metal were used for sacrifice and circumcision, and awls for boring holes in the ears. (Gn. 22, 6; Ex. 4, 25; 21, 6; Jos. 5, 3; Dt. 15, 17.) These procedures, castration and "uncircumcision" were probably the only operations. Inflammatory reaction following operative procedures is recorded in Gn. 34, 25. We hear of no tumors, benign or malignant. Burns must have occurred, but it is interesting and curious that nowhere in the Old Testament is any method given for producing fire. In II Sam. 21, 20, is mention of a giant—born so—with supernumerary digits, six fingers and six toes, twenty-four digits in all. In I Ch. 20, 6, his gigantism is described as hereditary. Moses is thought to have had some defect of speech. (Ex. 4, 10.) Legend says that when a boy he put a live coal into his mouth and burned his tongue, so that he was unable to pronounce the labials. It has been suggested, however, that Moses referred to his lack of practice in the Egyptian language. Lameness and blindness were common then as now. (II. Sa. 5, 6.) Just what happened to Jacob's hip when in his wrestling the angel "touched the hollow of his thigh" we do not know, probably a severe sprain of the hip and thigh or a severe injury to the sciatic nerve. The "sinew that shrank" was probably this nerve trunk or possibly an atrophied muscle. (Gn. 32.) Saul's grandson was lame in both his feet, due to his nurse having let him fall when he was five years old, a common history of lameness to this day. (II Sa. 4, 4; 9, 13.) Bone disease existed. (Lv. 21, 18-20; Pr. 14, 30.) A crooked back is often due to tuberculosis of the spine, and this was one of the physical blemishes that barred a man from the priesthood. Dislocations were known. (Job 31, 22.) There are possible references to fracture of the skull. (Jdg. 9, 53; II K. 1, 2.) Eli fractured his neck by a fall backward from his seat on hearing the news of the death of his sons and the capture of the ark. (I Sa 4, 18.) Fractures of the long bones were put up in splints. (Ezk. 30, 21.) There are three references to penetrating wounds of the chest, and three to penetrating wounds of the abdomen. (II Sa 4, 6; 18, 14; II K. 9, 24; Nu. 25, 8; Jdg. 3, 21-22; II Sa. 20, 10.) There are battle wounds and infected wounds. (I K. 22, 35; Ps. 38, 5.) No method is given for stopping hemorrhage. Wounds were washed, the edges drawn together and bound up in oil and wine. (Is. 1, 6.) There is a possible reference to leeches. (Pr. 30, 15.) The pathology of Pr. 20, 30 is very obscure. There is a suicide by hanging, another by the burning down of a palace, and King Saul fell upon his sword. Abimelech would have committed suicide had he been able.

Without question the common diseases of to-day existed in Old Testament times. In Lv. 26, 16, and Dt. 28, 22, there are possible references to such diseases as tuberculosis, typhoid, malaria, Malta fever, and smallpox. "The pestilence that walketh in darkness" suggests malaria. (Ps. 91, 6.) Certain conditions were termed incurable. There are possible references to affections of the heart. Men were gray haired and bald then as now. Diabetes is comparatively common among modern Jews, but no evidence is found of its existence among the ancient Hebrews. Scurvy almost surely prevailed during their desert wanderings. We do not know what was the "botch of Egypt"—possibly smallpox. (Dt. 28, 27 and 35.) Liver disorders and bowel disturbances were known. The latter are said to have been most common among the priests, because they went about so much in their bare feet on the cold floors of the temple. (Job 16, 13; Pr. 7, 23; Is. 16, 11; Jer. 4, 19.) The Hebrews knew that some disease was contagious, and they recognized the results of a fever. (Jer. 9, 21; Dt. 28, 22.) Beyond that they could not go. But we must not forget that the exact differentiation of most fevers has been made within the memory of men still living.

Of all diseases of Bible times and lands leprosy has always aroused the greatest interest. It was the most important and best known, was endemic in the land, and was considered infectious, contagious and even hereditary. Without question some, possibly much of the leprosy—so called—of the Bible, as well as that of the Middle Ages, was not leprosy at all. The term was applied to any rough, scaly skin condition. As a natural result leprosy was confused with syphilis and tuberculosis, and was often not differentiated from such skin diseases as eczema, ringworm and psoriasis. Leprosy, or at least scaly skin conditions, were common in Old Testament times. Lv. 13 shows the result of keen observation of the disease. The leprosy of garments and of houses was probably moulds or fungi (Lv. 13 and 14). As far as the writer can learn, the following are the only cases cited as leprosy in the Old Testament: (1) the hand of Moses becoming leprous (Ex. 4, 6); (2) Miriam becoming a leper (Nu. 12, 10); (3) the four leprous men before the gates of Samaria (II K. 7); (4) Naaman's leprosy and its transference to Gahazi (II K. 5); (5) the leprosy of King Uzziah (Azariah) (II Ch. 26, 19; II K. 15, 5.) Five references in all. Some palpably could not have been true leprosy. The subject is too big to enter into any further detail.

The plague is one of the oldest diseases of mankind. It existed centuries before Christ. It was the Plague at Athens. During the Middle Ages it destroyed one and a quarter millions of people in Germany alone. Seventy thousand died from it in London in 1664. It was the Black Death. It is to be seriously questioned whether the word plague as it occurs in the Old Testament means always the same disease; indeed, probably not. In the Old Testament the term plague seems to have been applied to any epidemic disease, usually occurring in cities or camps, rapidly fatal to a great number. Let us analyze the five epidemics among the Israelites. (1) the plague caused by eating the quail. (Nu. 11, 31–33). This sounds much like ptomaine, or meat poisoning, though it may have been the pulmonary form of the plague. (2) The disease among the spies sent by Moses to explore the region of the Red Sea (Nu. 14, 37). It is idle to speculate what this disease was, possibly cholera. (3) The plague that destroyed 14,000 after the rebellion of Korah (Nu. 16). This resembles the real Black Death more than any of the other epidemics, especially since it followed an earthquake. (4) The plague of Baal-Peor from which 24,000 died (Nu. 25). This was in all probability a venereal disease, most likely syphilis. Baal-Peor was a phallic god, and worship of this god seems to have been the ascribed cause of the disease. (5) A three days' pestilence that destroyed 70,000 (II Sa. 24, 13–15). This may have been the plague, cholera, or influenza. It is manifestly impossible to identify each epidemic with a definite disease as known to science of to-day.

In passing it may be well to call attention to the fact that the ancient Hebrews were prone to exaggerate numbers. For example, 600,000 warriors are said to have left Egypt, implying a total population of a million or more—an incredible number to have participated in the Exodus. In I Ch. 21, 5, it is stated that Israel had a population of over a million, with 480,000 warriors in Judah. When Sennacherib overran the country the Israelites numbered about 200,000 all told.

There are other plagues of the Old Testament that have caused much discussion. One is the sixth plague of the Egyptians (Ex. 9, 8–11). It was probably an eruptive disease accompanied by abscesses and ulcers—boils and sores. The two most plausible guesses are anthrax, or smallpox, for the disease affected both man and beast. This was probably the so-called "botch of Egypt." The death of the first born was probably due to some epidemic disease. Another is the plague of the Philistines (I Sa. 5). This was probably syphilis, and will be more fully discussed under the venereal diseases. One hundred and eighty-five thousand of Sennacherib's army are said to have been smitten by an angel (II K. 19, 35). We do not know what this visitation was. A great deal of energy has been expended in the effort to explain the "fiery serpents" that were visited upon the Israelites, and of which frequent mention is made (Nu. 21, 6; Dt. 8, 15; Is. 14, 29; 30, 6). Actual serpents and their bites may be meant. The term may be a euphemism for venereal disease. An ingenious explanation is that these fiery serpents were guinea worms. These worms are several inches long, enter the skin, especially of the legs, produce ulcers and abscesses, and are the cause of the so-called guinea worm disease that occurs in the East.

(To be continued.)

Geology in Relation to the Exact Sciences*

It is often said that figures can be made to prove anything; and certain it is that a series of arithmetical operations does sometimes serve as introduction to very strange conclusions. The fault, of course, is not in the tool, but in the hand that uses it. In the larger issues of geology especially, where the gulf to be bridged between data and conclusions is so often a wide one, ingenuity of reasoning ought surely to be accompanied by a due sense of responsibility in the handling of figures. Calculation, in such applications, is by no means so simple an art as it may appear. In wrestling with problems of the kind indicated, and, I must add, in reading some very fascinating speculations by geologists of high standing, I have often wished that some obliging mathematician would put forth a small manual of applied arithmetic for the guidance of workers in the descriptive sciences. There are absolutely necessary precautions to be observed when calculation is based upon data always partial and at best roughly approximate, and these precautions are too often neglected. To be safe, we must have some conception of the probable error attaching to our observations, and we must note how the initial errors may be multiplied in the process of calculation. Especially there is the cumulation of error which must ensue when results obtained in this fashion are used as links in a chain of deduction.

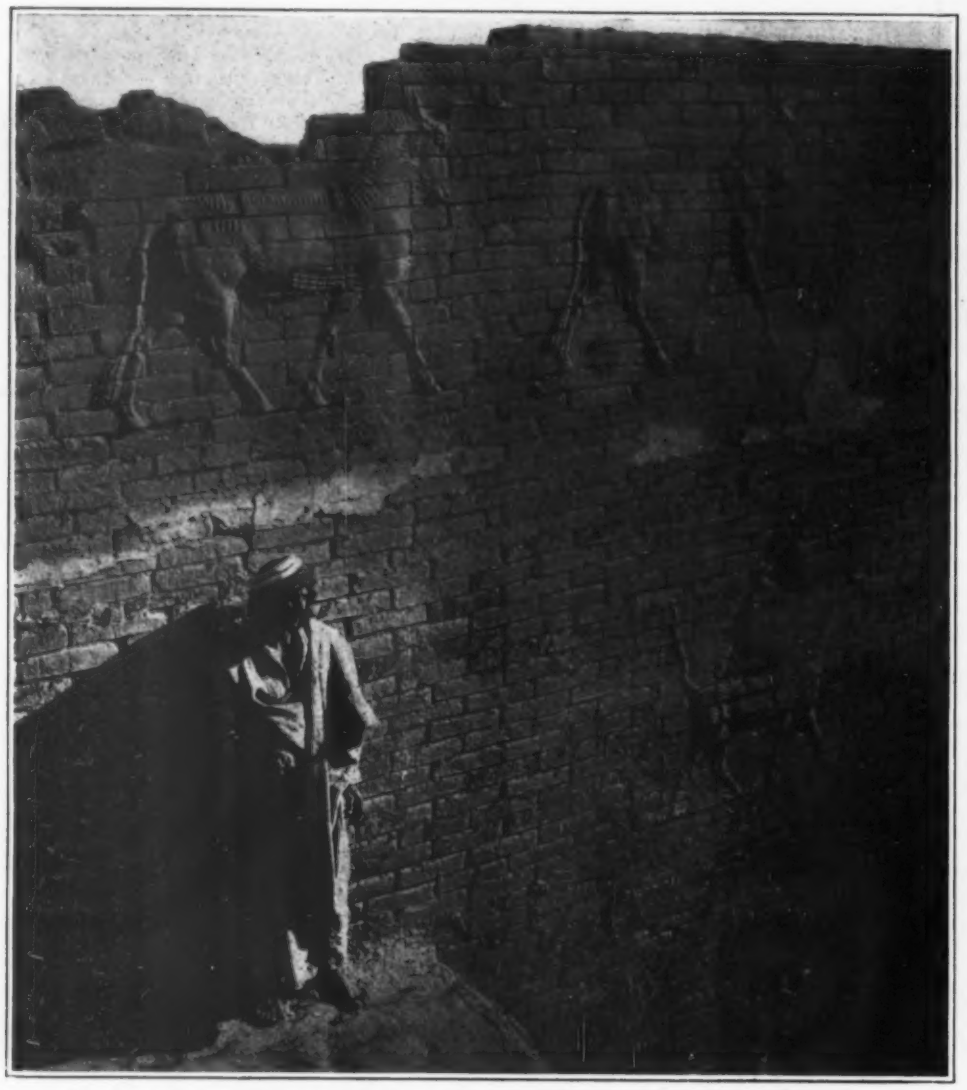
Without entering into these matters, some of which, as I have suggested, call for expert aid, I will take for illustration a single point, the frequent abuse of *the average*. Say that we wish to determine the amount of mud annually carried down by the Nile. Since there are variations, both seasonal and casual, we must take a sufficient number of observations, properly distributed in time, and an average, duly weighted, will then give us as good a result as the nature of the case admits. But now suppose that we wish to know the amount of sediment carried by all the rivers of the world. We have data for nine rivers, data which are likely to differ much in respect of probable error. Accepting them, however, as they stand, it appears that the water of the Rio Grande carries one part in 291 of sediment, that of the Uruguay River only one in 10,000, the other seven rivers giving intermediate values. The highest figure is thus thirty-four times as great as the lowest. Some geologists will simply take a mean of the nine figures, and proceed contentedly to use this result in the most far-reaching conclusions. I do not believe that a mean of nine figures so discordant can afford any information of quantitative value. The average must be extended over a much wider area, before a result is obtained of which we can make use.

Where dynamical principles enter into the problem, the pitfalls which await the unwary are sometimes less evident. I will take as an illustration the case of models, such as have been constructed to elucidate the mechanism of folding and faulting. In no case, so far as I am aware, have geologists had regard to the conditions which are necessary in order that a model may correctly represent the working of the original. The various forces concerned must bear their proper ratios. Since the weight (for a given material) is reduced proportionally to the cube of the linear dimensions, the other forces must be reduced in the same ratio; and it is, in fact, impossible to make this adjustment as regards the internal forces which resist deformation and fracture. Moreover, the velocities of the moving parts should be reduced in proportion to the square root of the linear dimensions; and this makes it hopeless to think of imitating the slow processes of mountain-building. Models of this kind may afford useful *geometrical* illustrations, but can throw no light on *dynamical* problems. The same remark applies to models of glaciers; but here there is no need to go to artificial models to illustrate my point. Some geologists still argue from the behavior of an Alpine valley-glacier to that of a continental ice-sheet, without perceiving how completely the different scale of magnitude must modify the mechanical conditions.

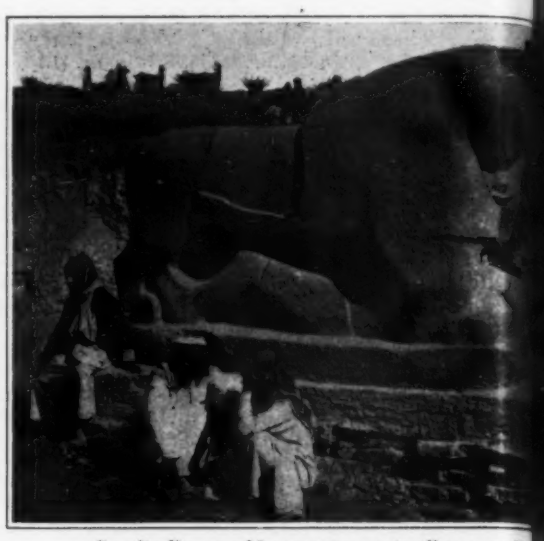
Experiment has undoubtedly afforded valuable help in the study of particular questions in the domain of physical geology, and this is to be recognized with gratitude. As regards the larger and more complex problems, however, imitative experiment labors under the same disadvantage as mathematical analysis. Any concrete problem can be treated only in an arbitrarily simplified form, and among the conditions which cannot be realized in the laboratory may be some which in nature are of vital importance. Especially will this be the case where the time element enters.

There is, however, another department of experimental geology in which we are justified in expecting results of very high value. I allude to the study of the conditions of formation and stability of different minerals, with the object of elucidating the mode of origin of igneous and other rocks. The artificial reproduction of many of the rock-forming minerals has engaged the attention of chemists, especially in France, during the last hundred years. Fouqué and Michel-Lévy succeeded even in imitating some of the simpler types of igneous rocks. These researches have furnished the petrologists with useful information, but it is information mostly of a very general kind. The laborious investigations now being carried out, more particularly in the Geophysical Laboratory of the Carnegie Institution of Washington, are of a different order, systematic and precise to the highest degree attainable. Their chief object is to apply to the crystallization of igneous rock-magmas the methods which have proved so fruitful in other branches of physical chemistry. This necessitates working over a far wider range of temperatures than is usual in laboratory operations, and must sometimes include high-pressure work also. It involves, too, other practical difficulties, arising especially from the slowness with which equilibrium is established in many of the transformations investigated. Owing perhaps to these obstacles, and partly, it may be, to the scarcity of enlightened millionaires—research on these lines has not yet been widely taken up.

* From a Presidential Address delivered before the Yorkshire Geological Society by Alfred Harker, F.R.S. Reprinted from the *Proceedings* of the Society.

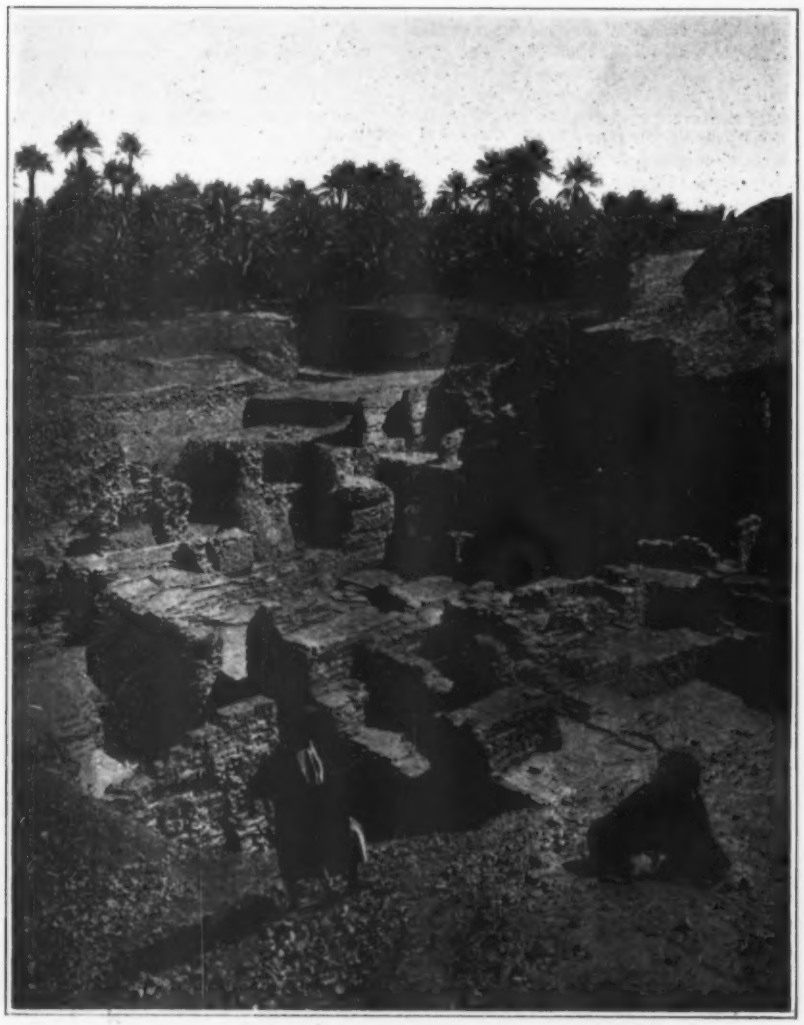


The Ishtar Triumphal Gate. The lower figure is the mythical monster, the Mush-Rush.



Granite lion crushing a man or standing over hi

General view, showing Ishtar Gate and processional ed edifi



The excavations on the mound of the royal capital of Babylon.

Round-roofed tombs of the Assyrians, built of sun-dried thin rectangular

Underwood

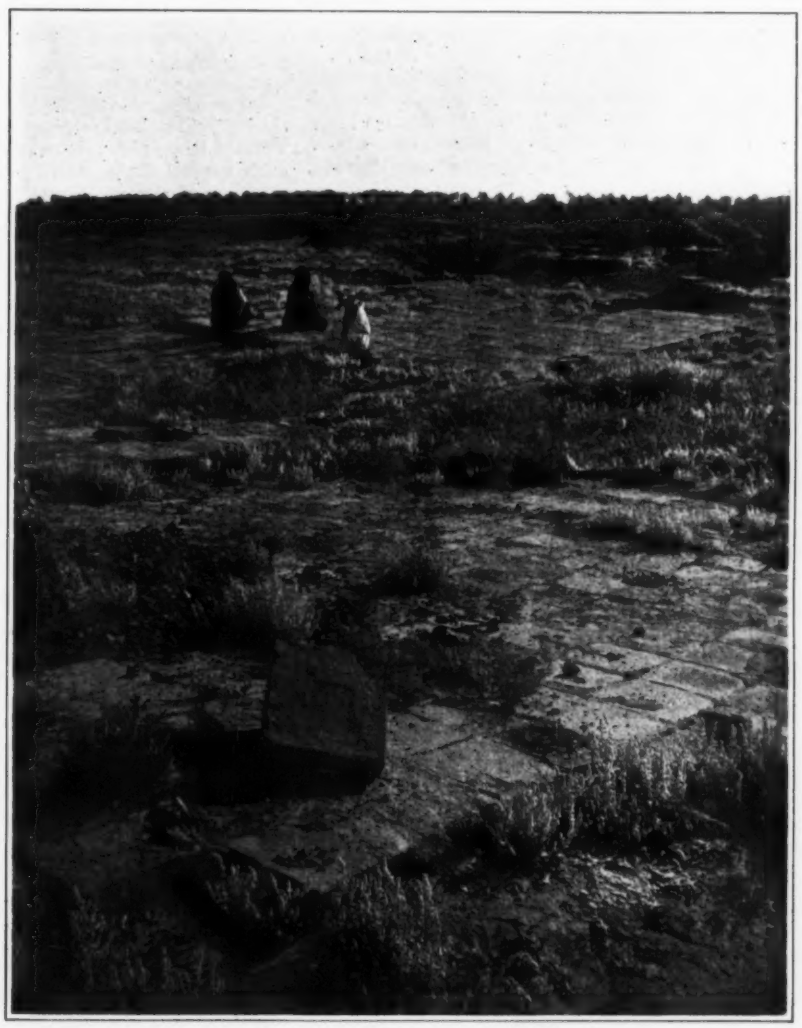
THE GERMAN EXCAVATI ITE C

Fragments of sun-baked oval vessels.

ned edifices erected by Nabopolassar and Nebuchadnezzar II.

Trench leading to streets and foundations of Nebuchadnezzar's royal city.

Excavations on the site of the famous Esagil Temple.



Flooring of the supposed throne hall of Nebuchadnezzar.

SITE OF ANCIENT BABYLON

Recent Progress in Astrophysics—III*

Many Important Discoveries That Add to Our Knowledge of the Heavenly Bodies

By Prof. C. G Abbot

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2064, Page 63, July 24, 1915

IT IS found that the fainter stars are on the whole at greater distances from the sun than the brighter ones, so that the star list of Boss relates on the average to a system of stars at a greater distance from the observer than the star list of Campbell. A reason has already been assigned for supposing Boss's value of the solar motion too high. It may be on the other hand that the sun's motion is to some extent shared by the stars which are its more immediate neighbors, so that its velocity with respect to them is smaller than with respect to the stars which are more remote.

Prof. Campbell has adopted in his later discussions the round numbers 270 degrees right ascension and 30 degrees declination for the position of the solar apex, and the velocity of 19.5 kilometers as the rate of its motion toward this apex.

With these quantities determined, it is possible to take from the observed radial velocity of each star a component which depends upon the motion of the sun, and thus to leave to each star its own individual motion with respect to the earth, as the earth would be if fixed in space with reference to the whole system of stars considered. As the sun moves at the rate of 19.5 kilometers per second in a certain direction, so for each of the other stars investigated, there should be a certain velocity and direction of motion. The stars have been classified at the Harvard College Observatory under the direction of Prof. E. C. Pickering, with regard to the nature of their spectrum. The principal groups of the Harvard classification are designated by the letters B, A, F, G, K, M. The peculiarities of these types of spectra are indicated in the accompanying plate 3. We see the progressive greater complexity of the spectra from type to type. Campbell points out the very interesting fact that the more complex the star spectrum, the greater the velocity of the star in space, with regard to a point so fixed that the algebraic sum of the velocities of all the stars with respect to it is 0. The same conclusion is derived independently by Boss from a consideration, not of radial motions, but of thwart motions of the stars. The results of Campbell and Boss are compared in the following table. We assume for Boss's results as for Campbell's that the velocity of the solar system toward its apex of motion is 19.5 kilometers per second, thus the angular motion observed by the telescope may be converted into its linear equivalent. Unfortunately the grouping of stars by the two observers is different as regards the subclasses of the Harvard classification.

Campbell.			Boss.		
Classes.	Number of stars.	Component of peculiar velocity (km. per second).	Classes.	Number of stars.	Component of peculiar velocity (km. per second).
B–B5....	*312	6.2	Oc5–B5	490	6.4
B8–B9...	90	6.7	.....	.....	.....
A.....	172	10.5	B8–A4..	1,647	9.9
F.....	180	14.4	A5–F8..	656	15.8
G.....	118	15.9	G.....	444	18.1
K.....	346	16.8	K.....	1,227	14.7
M.....	71	17.1	M.....	222	16.7
	1,289			4,686	

*For 132 of these stars the radial velocity is estimated.

The reader must note that the results, both of Boss and of Campbell, relate only to a certain component of the motion of the stars. In the case of Boss it is derived from the component of the proper motion, which is at right angles to the solar pathway; and in that of Campbell it is that component of the radial motion which is in the plane of the star and the solar pathway and is at right angles to the solar motion. If it is assumed that the stars have no preference for motion in one direction rather than another and that they are well distributed over the whole celestial sphere it follows that the values above given from both observers are but half the average velocity of the group of stars, considering their motions in the real directions which they have in space, and not merely the components of motion found by Boss and Campbell. Thus we find for stars of group G, to which our sun belongs, an average velocity of 32 or more kilometers per second, which is considerably greater than 19.5, which is assigned to our sun.

*Annual report of the Smithsonian Institute, 1913.

The Milky Way, composed as it is of a vast number of stars, has long been a circle of reference in the heavens for the discussion of the distribution of the stars. Not only are the individual stars crowded more closely in the Milky Way than elsewhere, but the crowding is different with different spectral types. Thus Prof. Pickering pointed out in his discussion of Harvard Revised Photometry that the stars of the early types, type B especially, were to be found preponderatingly in the neighborhood of the Milky Way. This tendency of the stars to distribute themselves differently with respect to the Milky Way has been summarized by Prof. Boss in the following tables, in which he gives the numbers of stars of different spectral types to be found in zones at different distances from the center of the Milky Way, and also the numbers of stars of the different types which occur in equal areas in these zones, assuming for the zone +10 to —10 degrees a number of 100. We see that the stars of the so-called "later types" G K M are nearly uniformly distributed over the heavens, but that the stars of the "early types," especially B, are very unequally distributed, and crowd more and more toward the Milky Way.

ENUMERATION OF TYPES IN GALACTIC ZONES.

Zone.	Limits.	B	A	F	G	K	M
	Degrees.						
I	+10 to —10	237	422	142	103	237	33
II	±10 to ±30	105	310	104	63	205	34
III	±30 to ±50	14	170	89	66	155	31
IV	±50 to ±70	5	100	51	30	102	24
V	±70 to ±90	2	32	13	12	32	5

RELATIVE AREAL DENSITIES IN PERCENTAGES.

Zone.	Limits.	B	A	F	GKM
	Degrees.				
I	+10 to —10	100	100	100	100
II	±10 to ±30	47	78	78	87
III	±30 to ±50	7	53	82	84
IV	±50 to ±70	5	47	72	84
V	±70 to ±90	5	44	53	76

In several respects the stars of class B are very remarkable. Dr. Campbell has stated that in a space concentric with the sun, which must contain hundreds of stars of other spectral classes, there would probably not be a single one of class B. Thus, B stars are, on the whole, excessively remote. In the second place, they seem to be very bright stars, for, as Prof. Pickering states, a count of the class B stars indicates that of the bright, visible stars one out of four belongs to this class, while of the stars of the sixth magnitude there is only 1 out of 20, and that few, if any, would be found fainter than the seventh or eighth magnitude.

It has been strongly intimated by such men as Kapteyn, Campbell, and Boss that the order of spectra B, A, F, G, K M indicates substantially the order of development of the stars in time, so that the stars of class B may be regarded as the younger stars, and those of classes A, F, G, K and M, successively, older and older. Prof. Boss goes so far as to say: "There can scarcely be a doubt that the same stars that are now seen of the spectral type A were in past ages of the spectral type B, and then at a mean velocity of approximately only two-thirds or three-fourths that which they have at present. It seems equally probable that A stars of the present will eventually become stars of the second[1] type in the future, and along with that physical development will acquire an increase of mean velocity about 50 per cent greater than that those stars now have. This fundamental fact of acceleration in the means of the stellar motions must have a vital bearing on questions of stellar development."

It is known that the spectrum of the general surface of the sun, which is like that of stars of class G, goes over into the spectrum of a sun spot, which is like that of stars of class K, by a mere lowering of temperature. It is also known of all bodies with which we are familiar upon the earth, that when, as time passes, they lose energy by radiation they cool. Accordingly it seems probable that stars of class G will at length reach the condition of class K by the mere cooling incidental to the continuation of their radiation to space through long periods of time. The gradual progress in form of spectrum from class B to class M, the gradual progress in velocity of motion from class B to class M, the gradual progress in distribution in space from class B to class M, and other lines of gradual progress which could be named, all seem to show that the arrangement of the stars according to this classification corresponds to the march of a fundamental progress in nature. That this progress is in point of time from stars of simpler spectrum to those of the more complex, and not the opposite, is indicated by the consideration with regard to the sun-spot spectrum which I have just cited.

In contemplation of these various facts Prof. Campbell has remarked as follows:

"The close relationship of the class B stars to the Milky Way, their low radial and tangential velocities, the apparent absence of class B stars in both near space and distant space, a clustering of many of these stars in apparently related groups—for example, in the Orion region—lead us to believe that the present class B stars assumed stellar form in regions relatively near their present positions. They may have originated from comparatively few great separate collections of matter in or near the plane of the Milky Way. The variety of motions which we observe in the stars in one of these apparent groups might, perhaps, have originated from the influence of the passing of many individual stars through the immense volume of space occupied by the group. The absence of class B stars in our vicinity may indicate primeval vacancy in this region, or the development of the stars in this region to an effective age beyond that corresponding to the class B spectrum."

Kapteyn has said:

"As the younger the stars are the smaller are their internal motions, it follows at once that from whatever matter our youngest stars—the helium stars[2]—may have been evolved, that matter must have in all probability still smaller internal motion. Let us call this matter primordial matter. As the internal velocity of the helium stars is already so very small, we come to the conclusion that primordial matter must practically have hardly any other motion than the motion of the cloud to which it belongs."

The statements quoted above, and many others which might be quoted from astronomical literature, lead us to the conclusion that their writers assume the following evolution of the universe, beginning from the nebula, and proceeding with passing time to the stages of the classes B, A, F, G, K, M in spectra. Originally the matter had very low velocity in space, and as the stars were formed and grew in age their velocity became greater and greater. Whatever the drift which the original primordial matter may have had, the formation of the stars and the gravitation which they mutually exert, together with their increasing velocity in space, tended to alter the motions of the stars from a slow drift in some particular direction to a much more rapid progress of individual stars in every conceivable direction. This motion naturally took the stars of the later types farther and farther from the original seat of the primordial matter, so that now, although we find the class B stars still mainly confined to the neighborhood of the Milky Way, yet for other types of stars the dispersion has gone farther and farther. For stars similar in constitution to our sun, and naturally of the same order of age as the sun, the circumstances of the wandering have naturally been much the same, so that we find the stars of approximately the spectral class of our sun to be, on the whole, in the less remote parts of space. When, however, we consider the stars of most advanced type, of spectral class M, whose wanderings have continued for the most untold ages, we find these stars as a class in the more remote parts of the universe.

Although this speculation is supported by a good many facts of observation, yet it is only fair to state that there are astronomers of very high eminence who consider either that the time is not ripe for such speculations, or that the evidence may equally well be arranged to suit other conclusions. If we assume the line of speculation stated above, we must be interested in the following statement of Prof. Kapteyn:

"There is another problem involved in our observations which might seem to be of no less importance than the one just now considered. How have we to explain the fact that the internal velocity of the stars increases with age? The astronomer who, in the study of the motion of the heavenly bodies, has found hardly a trace of any other force than gravitation, will naturally turn to

[1] Of Secchi's classification, in which B to F types are I, G to K are II, and M is III.

[2] Class B. 44863 deg—s mJ1913—3.

gravitation for such an explanation; and it really seems a necessity that under the influence of their mutual gravitation, bodies which at the outset have little or no relative motion must get such a motion, which, up to a certain limit at least, will increase with time. Thus far there is no great difficulty. But now let us look further back in time, back to the time in which the stars had not yet been formed, in which matter was still in its primordial state. If it be true that mutual attraction of the stars has generated such an enormous amount of internal motion in the time needed by the stars for their evolution from helium to second or third type stars, how have we to explain the fact that we find that same matter nearly at rest at the first stage of stellar life? That in the prehelium ages gravitation had produced hardly any motion? He who believes in a creation of matter at some finitely remote epoch may find no difficulty in the question, but to him who does not, there is something astonishing to see matter behave as if there were no gravitation. What may be the explanation? Is there really no gravitation in primordial matter, or is there another force exactly counterbalancing its effects?

"I have no solution to offer. I simply wish to point out that here is a great problem, which in my opinion deserves the attention of the physicist no less than that of the astronomer."

The Larger Ions in the Air

In addition to the well-known small ions, which are of a type common to all gases, two classes of larger ions exist in the air under ordinary conditions. One of these consists of the large ions of Langevin which have a mobility of about 1/3000, while the other contains ions with a mobility of about 1/50. As the later value lies between those of the mobilities of the small and large ions, the members of this latter class may be called the ions of intermediate mobility, or, shortly, the intermediate ions.

The slow movement of these larger ions in an electric field clearly indicates that they are molecular clusters of more or less complexity. Ordinarily the value of the mobility is the only guide to the nature of the ionic structure, but in the case of the large ion at least, an important deduction is to be made from the outcome of experiments on the formation of clouds in closed vessels.

It is well known, since Aitken's notable work on the subject, that, in ordinary circumstances, the air is crowded with particles, in suspension, on which the water vapor condenses into visible drops if the air becomes slightly supersaturated. These particles, the number of which varies greatly from time to time, can be removed by filtration of the air through cotton-wool, or, in closed vessels, by settlement with the drops formed by expansions. In general, these nuclei are electrically uncharged, and whatever their nature, are conveniently known as dust particles.

C. T. R. Wilson has shown that in air recently freed from dust, with increasing supersaturations, the first visible condensation takes place on the small ions. It is now known that the circumstances of the condensation remain unchanged during intervals of time extending to days after the removal of the dust. The intermediate and large ions are eminently suitable nuclei for the condensation of water vapor, as their mobilities are largely affected by changes in the hygrometric condition of the air, so the results just mentioned indicate not only that these ions are removed with dust particles, but also that they are not produced in air once made dust-free. There is no doubt that the large ions are present in ordinary saturated air; it appears, then, that filtration removes some rigid nucleus without which at least the large ion cannot be developed.

From the facts which have been stated, the picture of the large ion most readily formed is that of a dust particle round which water molecules are adsorbed to an extent depending on the vapor pressure, the whole being electrified by the attachment of a small ion.

Some idea of the nature of the relation between mobility and vapor pressure which is to be expected in connection with such an ion, may be obtained by comparing, on simple thermodynamic lines, the working of two Carnot's engines, one with unit mass of a mixture of ions and water vapor as the working substance, and the other with unit mass of water and its vapor. The vapors are to be taken as perfect gases, and it is to be assumed that the density of a vapor is small compared with that of the substance in the corresponding denser state. With these assumptions the result is readily obtained that $(p_1/p_2)m = (P_1P_2)1/n$, when only the change of state is being considered. p and P are the values of the vapor pressures in the two engines at the same temperature, and n is the ratio of the latent heat of vaporization of water to that of the fluid surrounding the nucleus of the ions. It is convenient here to take m as the mass of the denser part of the substance. The expression, which holds for all cases of adsorption, states that at two temperatures the mass adsorbed will be the same if the ratio of the vapor pressures, in equilibrium with the adsorbed fluid, is the nth root of the ratio of the saturated vapor pressures at those temperatures. It is the formula of reduction for adsorption observations taken at different temperatures, and a clue to the condition of the adsorbed moisture is to be obtained from the value of n found necessary to make the observations fall into line. As the mobility of the ions under consideration, at constant temperature and air pressure, is constant if the mass of the adsorbed fluid remains the same, the formula is directly applicable to mobility determinations if m is taken to refer to the mobility reduced to constant air density.

Trouton, and Masson, and Richards find that the mass of contained moisture in the case of flannel and cotton-wool is a function of the relative humidity. This means that n is unity in the preceding expression. n is also unmistakably unity in connection with the large ion, the determinations of mobility only falling into line if plotted against the relative humidities. The result of such a plot is shown in Fig. 1.

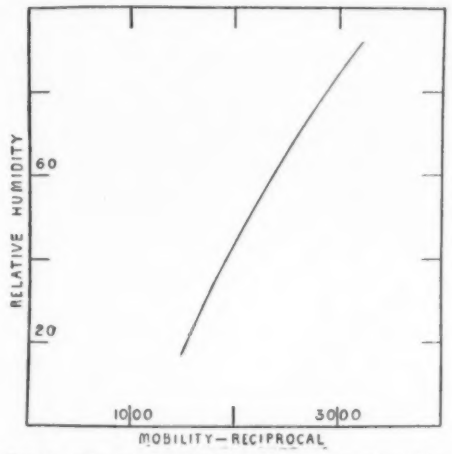


Fig. 1.—The relation between the reciprocal of the mobility of the large ion and the relative humidity.

No heat change due to a variation of surface energy is involved in the value of n, so in these cases where $n = 1$, as the heat per unit mass necessary to annul a temperature change due to the mere alteration of state is the same as that required to keep the temperature constant when water evaporates, it may be definitely concluded that the molecules in the contained or adsorbed fluid are in the same condition of aggregation as those of water.

In the case of the intermediate ions the determinations of mobility are not accordant enough to allow the value of n to be found in this way with any accuracy, but the fit of the points to a line is on the whole better if the mobilities are plotted against vapor pressures

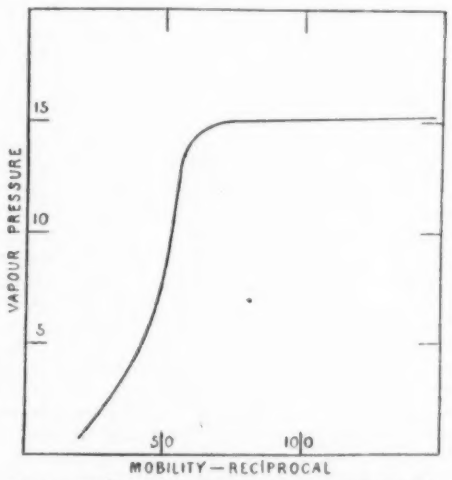


Fig. 2.—The relation between the reciprocal of the mobility of the intermediate ion and the vapor pressure.

than when set out against the relative humidities. This, according to the preceding expression, corresponds to the physically extreme case when n is equal to some large number, though, so far as could be inferred from the plot, n might not be greater than some small integer. In any case, here the latent heat of vaporization of water is sometimes greater than that of the adsorbed fluid.

The result of the preceding line of argument, though not conclusive in the present instance, at least suggests the idea that the intermediate ion consists of a rigid core enveloped by a collection of water molecules existing as a dense vapor rather than in the liquid condition.

Trouton, in 1907, made the interesting discovery that there are two modes of condensation of water vapor on rigid surfaces. If special precautions are taken in drying the surfaces, on exposure to water vapor adsorption occurs as a dense atmosphere of water molecules, in a state, perhaps, intermediate between that of a gas and that of a liquid. At any rate, a change to the liquid condition somewhat abruptly takes place in these circumstances when according to Trouton, the humidify is about 50 per cent in the case of glass, and about 90 per cent in that of shellac.

The fluid surrounding the nucleus of the intermediate ion is, no doubt, in a state corresponding to that of the moisture condensed at low pressures on carefully dried surfaces in Trouton's experiments.

Further evidence supports the preceding view of the ion. Fig. 2 shows the relation between the reciprocal of the mobility of the intermediate ion and the vapor pressure as readily deduced from a plot of the determinations.

At a pressure of about fifteen millimetres the mobility decreases very rapidly with increase in the value of the vapor pressure. Simultaneous observations of the intermediate and large ions were obtained on many occasions, but with vapor pressures exceeding seventeen millimetres, while the observations of the large ion were equally good, all trace of the intermediate ion disappeared.[1] Disintegration of the ion at a critical vapor pressure is unlikely, and it is much more probable, assuming a rigid nucleus, that the adsorbed fluid is in the condition of a dense vapor, and that at the critical pressure it changes its state to that of a liquid, like the moisture adsorbed by glass and shellac in Trouton's experience.

Such a change means a decrease in the energy of the aggregation, and is to be expected when the molecules of water vapor around the nucleus become sufficiently closely packed. The advent of a liquid surface involves a diminished rate of molecular escape; rapid condensation will therefore occur, with a decreasing unit-surface energy, until further increase in the size of the ion means an increase in the total energy of the mixture of ions and vapor. The final result is, no other than the large ion. The assumption of a rigid core for the intermediate ion appears, thus, to be justified.

To sum up the whole evidence, the large ion consists of a rigid nucleus surrounded by moisture in the liquid condition, the size of the drop at constant temperature depending on the vapor pressure. The intermediate ion is to be considered as a similar nucleus enveloped by a dense atmosphere of water vapor. The mass of the ion increases with the vapor pressure, until at a critical pressure the adsorbed fluid assumes the liquid state, and the aggregation develops, by the rapid condensation which ensues into the large ion of Langevin.

It is not quite clear how the electrical energy of the ions is related to their diameter. The charge is, however, not essential to the equilibrium of molecular structures such as those just mentioned, and it is not unlikely that the conclusions as to the nature of the ions, only rendered possible by the happy chance of their electrification, may apply with, perhaps, little modification to the far more numerous class of unelectrified nuclei which exists in ordinary air.—J. A. Pollock, in *Nature*.

Acquired Radio-Activity

Some experiments by W. Crookes are given in the *Philosophical Transactions* of the Royal Society, 214, p. 433. When diamond, ruby, garnet, gold, platinum, yttria, calcium sulphide, zinc blende and barium platinocyanide are bombarded in a high vacuum by cathode rays, in no case can any permanent activity be recognized either by photographic or electrical means. By direct exposure to radium, however, many of the above substances become colored, the color depending on the substance. Diamonds take a full sage-green tint, the depth depending on the time of exposure. In addition to change of color diamond becomes persistently radio-active, continuously giving off α-, β-, and γ-rays. The acquired color and activity withstand the action of powerful chemical agents, and continue for years with apparently undiminished activity. Removing the surface by mechanical means, however, removes both color and radio-activity.

[1] Details of these observations will be found in two papers published in the *Philosophical Magazine* for April and May, 1915.

The Uniflow Steam Engine*

A Modern Construction That Promotes Economy

THE fact is established, not only by numerous and repeated tests, but by everyday practice, that the uniflow engine requires only about the same amount of steam as a compound engine. Here is one way of accounting for it.

A 100 per cent engine, i. e., an engine that could turn into work all the heat set free by working steam between 150 pounds gage, 100 degrees superheat, and atmospheric pressure, would run on about 13½ pounds of steam per hour per indicated horse-power. The best actual engines require 17 or 18 pounds.

If an engine used 18 pounds per horse-power hour, it would develop 1/18 of a horse-power hour per pound of steam. A horse-power hour is equivalent to 2,544.65 B.t.u. Hence, the engine converts

$$2{,}544.65 \div 18 = 141.4$$

of the 1,252 B.t.u. which is brought into it with each pound of steam into work.

If the engine had no losses it could run on 13.5 pounds per indicated horse-power hour, and convert

$$2{,}544.65 \div 13.5 = 188.5 \text{ B.t.u.}$$

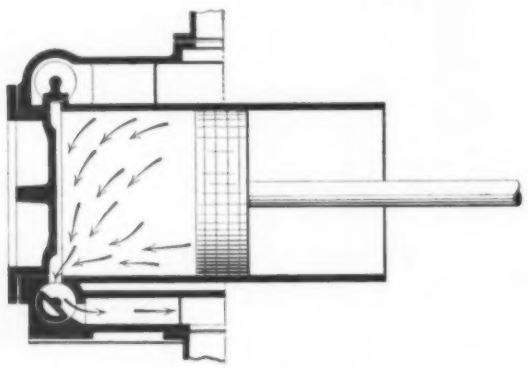


Fig. 1.—Counterflow type.

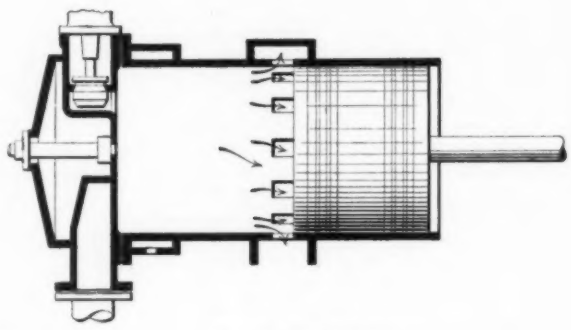


Fig. 2.—Uniflow type.

What becomes of the difference between this and the 141.4 B.t.u. converted by the best actual engines and the much less converted by the less efficient types?

The heat which is carried into the engine cylinder by the steam can get out in only three ways:

Radiation;

Conversion to work;

In the exhaust.

And it has got to get out as fast as it goes in, or it will accumulate in the cylinder and melt it down.

The radiation loss from a well lagged cylinder is trifling. It is evident that most of the unutilized heat escapes in the exhaust.

How does it get there?

It is absorbed by the containing surfaces, the cylinder walls, port surfaces, cylinder, and piston heads when the steam is hotter than they are, i. e., through a large part of the forward stroke, and given out to the exhausting steam throughout the entire return stroke, or until, by compression, the temperature of the inclosed steam equals that of the walls.

Whatever goes to nullify or to discourage this transfer of heat between the working medium and the containing surfaces, tends to reduce this bypassing of the heat from the hot to the cold side, from the steam chest to the exhaust, without doing work, and hence tends to increase the efficiency of the engine.

Suppose a cylinder could be so thoroughly jacketed on heads and on barrel with steam so hot that the inside skin of the containing surfaces would be as hot as the entering steam. When the steam came in it would remain in a vaporous or gaseous condition, instead of some 20 per cent condensing upon the cooler iron, as in the usual case, and it would retain its initial condition until cutoff occurred and expansion commenced. Then it would commence to cool and to absorb heat from the containing surfaces. Perhaps it has some superheat in its initial condition, so that it will not commence to condense immediately, or until the temperature has been reduced by expansion enough to use the superheat all up.

Superheated steam, dry steam, is a very poor absorber of heat. The heat from the cylinder head can radiate or "shine" through it, as the heat from the sun can radiate through the air without warming it up much. It is only when the sun shines on the rocks, and other substances which will readily absorb its heat, and then the air passes over them and picks the heat up by convection, that we get an energetic heating effect. The mere shining of the sun through the air heats it but little, as witness the temperature at elevations where there is little solid material, as compared with the exposure, to absorb and radiate the heat.

Under these conditions it can readily be conceived that even after the expansion has proceeded until the steam is below the saturation point, or even if there is initial condensation, the film in immediate contact with the hot surfaces gets dried out and superheated. Then the absorption of heat from the surfaces stops or becomes very slow.

The effect is analogous to that produced when a stratum of air gets around the cooling surface in a condenser, or when, in a boiler with poor circulation, the steam does not get readily away from the heating surface, or when, in a high vertical radiator, an inside pipe is so smothered that the already heated air hugs it instead of getting away and allowing other and cooler air to come up and be heated. So long, in the case of the engine, as this blanket of highly heated steam can be kept against the hot surfaces, there will be little transfer of heat to the contents of the cylinder, to be carried off in the exhaust.

Now, in the case of the counter-flow, or usual, type of engine, where the exhaust and the steam valves are both at the same end of the stroke, there comes, when the release occurs, an immediate rush of the steam backward toward the hot head, in a struggle to get out at the open exhaust port, as shown in Fig. 1. This steam, even if it were superheated to start with, has become cool and moist by expansion and conversion, with consequent condensation, of more of its heat into work than it could spare and remain dry. The protecting blanket of superheated steam is swept away from the hot surfaces of the entering end, and the cold wet steam impinging upon these surfaces absorbs heat from them by evaporation and convection to be carried uselessly into the exhaust or to make more work for the condenser. In a single-valve engine, where the same port is used for inlet and exhaust, even the surfaces of the port through which the hot entering steam must come are washed and cooled by this heat-absorbing mixture of low-pressure steam and water.

With the uniflow, or central-exhaust engine Fig. 2, there occurs no such reversal of flow. When the piston passes over the central port the steam is released from that end of the cylinder, the hotter steam at the head or jacketed end simply expanding and pushing the cooler wetter steam before it. The protective blanket on the cylinder head and the hot end of the cylinder is not swept off, but remains intact, and all the heat which is carried to the exhaust is that which the steam in the exhaust end of the cylinder can pick up in sweeping over the cooler piston head and the walls near the exhaust port, as it is pushed out of that port by the expansion of the rest of the steam from the pressure at release to that of the exhaust or condenser, and by the backward movement of the piston up to the point where it again covers the central port—usually about one tenth of the stroke. When the exhaust port is covered there is the volume of the return stroke yet to be completed, plus the clearance volume, full of steam of the exhaust pressure; that near the piston probably at a temperature corresponding to its pressure, that in contact with the hot head superheated considerably above that temperature. As the compression proceeds the temperature rises with the pressure, and there will be some condensation against the piston head, which is now absorbing heat that will be carried off in the next outrush of exhaust, but when the compression stroke is completed the clearance will be full of steam of practically the initial pressure, the cylinder head and clearance surfaces will be good and hot and the piston head as hot as it could get by taking heat from the compressing steam, so that the entering steam is received upon surfaces of about its own temperature and initial condensation much reduced.

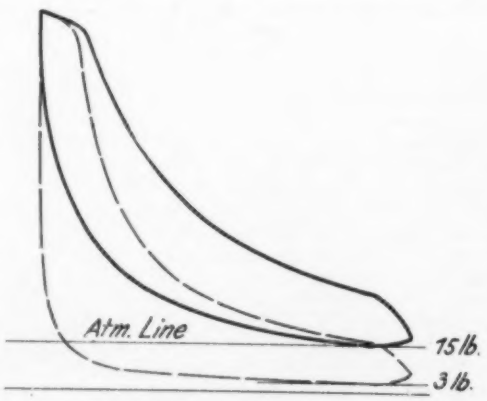


Fig. 3.—Indicator diagram.

A correspondent, in saying that he would not care to maintain a condenser which was in communication with the cylinder for only one tenth of the stroke, loses sight of the fact that the diminution in the back pressure endures throughout the stroke by reason of the lower initial compression pressure. Fig. 3 will make this plain. The full line represents the counter-pressure running non-condensing, the dotted line condensing, the exhaust port closing when the return stroke is one tenth completed in both cases. The diagram ought also to make plain to our correspondent that the method by which he computed the absolute back pressure at half stroke to be 18 pounds absolute has something the matter with it.

Aid to Astronomical Research

IN a communication to *Science* Prof. Edward C. Pickerings says: "The experience of the Rumford, Elizabeth Thompson and certain other research funds shows that great returns may be obtained from relatively small grants to suitable persons. Owing to the excellent organizations resulting from the large sums given to astrophysics in this country, astronomers are well qualified to secure such results."

In accordance with this idea, Prof. Pickering wrote to twelve American astronomers asking what use they make of such grants, if obtainable, and the replies received appear to demonstrate that a large amount of very valuable work could be accomplished by the expenditure of a comparatively small sum of money annually.

"An unexpected result was that, in nearly every case, the principal need proved to be for assistants. Some preferred one experienced observer, others two computers. In some cases it is believed that if the work were once started it would be continued by the university. An astronomer can often direct one or two assistants so that they will obtain as accurate results as if he devoted the same time to the work himself. A small appropriation may thus double the output of his observatory. Even if only a portion of the sums asked for could be provided, it is probable that an extraordinary relative output would be obtained. It is hoped that, in some cases, those interested in a particular observatory may be willing to supply its needs."

* Courtesy of *Power*.

Suggestions in Mechanisms

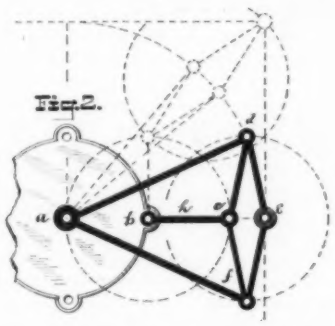
Some Curious Geometric Properties of Articulated Levers

By S. D. Mott

It is much to be doubted if in all the literature of mechanics there exists another combination of articulated self-contained members that is capable of the practically unlimited variety of action to transfer motion, or trace the markings of triangulation and geometric diagraming, than is illustrated herewith. In the field of mechanical movement its infinite variety may be compared to what the kaleidoscope is to vision, or the slide-rule to calculation. The theory of the combination is such that it may have unexpected uses in machine design and general engineering work and therefore be of interest to geometricians, mechanicians, draftsmen and engineers.

Three arrangements only are shown, any one of which may be changed in direction of action, in proportions, or in dimensions illustrative of diversification. The fulcrums and pivot-joints are shown fixed, but it is easily seen that, with thumb-screw adjustments to make desired shifts of extension or contraction, a great diversity of results may be attained with a single instrument. It was devised by the writer in 1880 for Edison's balance-beam chemical meter, which, though an ingenious thing, was altogether too much involved and complicated for commercial usage.

The lever members in the figures are shown in black and the pivots or fulcrums in white for clearness. Consider (1) the single combination to the right of Fig. 1; (2) its duplication extended beyond fulcrum *a* to *a* walking-beam with *e e'* as working centers on two sides; (3) the bell-crank, as in vertical dotted lines, with *e e''* working-centers for right angle movement on two sides; (4) or on three sides *e e e''*; (5) a double walking-beam as indicated with 4 working-centers at right angles on 4 sides; (6) a beam bent at right angles to



the plane of the paper (not illustrated) with centers working at the two ends of a right angle in plan; (7) a spider combination (Fig. 3) with 3 centers working at other than right angles on 3 sides. A few of its markings are visualized to demonstrate its many-sided possibilities.

To study it for practical uses in mechanics, etc., it is recommended as advisable to lay out this device and then cut it out from pasteboard or wood strips, join together with pivots, and mount on drawing board or table. Its many-sided variableness will be found an excellent exercise for the imagination.

With the 6 coupled member and their controller *h* to the right of Fig. 1, all conic sections can be formed, parabola, hyperbola, ellipse and unsymmetrical sections like ellipse with curvature on one side greater or less, in any degree within its scope, than the curvature on its opposite side. And, further, the major and minor axes may be varied relatively *ad infinitum*, either symmetrically or otherwise; and, further, by manipulation, even trapezoids and trapeziums are triangulated. By just as many centers *b* as can be located between the fixed fulcrum *a* and pivot *c*, by just that many will be the varied modifications of its markings in the plane of the paper.

By as many centers of circles as can be located between *a* and *c* a like number of concave or convex curves (or reverse curves) are described within the scope of its movement and indicated at 1, 2, 4, 5, all deviations from the straight line 3, which is determined by *b* being located *exactly* half-way between *a* and *c*. When *a* and *b* coincide the result of movement is a circle shown in dotted lines, with *a* as its center.

In Fig. 1 the limit of travel of the working-centers *e e* is from 3 to 3'. By changing proportion, as in Fig. 2, the travel is to the corner of a square. By extension to a walking-beam all actions are duplicated on 2 sides; or a double walking-beam the duplications are on 4 side, and one-quarter of a revolution makes a perfect square. With thumb-screw adjustment referred to, these duplications may be similar or dissimilar—e. g., shifting of centers *b* equally between *a* and *c c'*, etc., respectively, will cause like markings on 1, 2, 3 or 4 sides of a perfect square, while unequal shifting of these centers will cause unlike markings on the 1, 2, 3 or 4 sides of said square.

The function of Fig. 3 is the same as Fig. 1, only

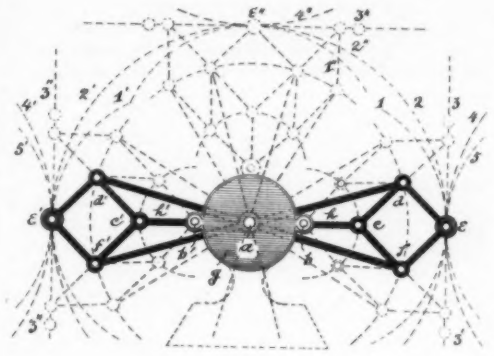
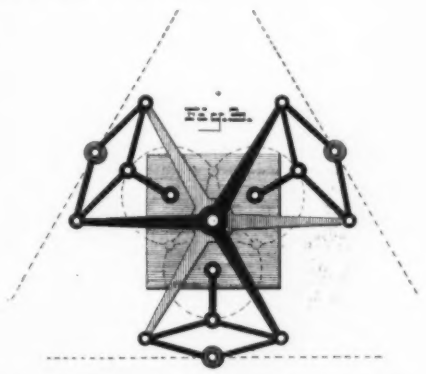


Fig. 1.

dealing with diagrams of 3 sides. As shown, it describes an isosceles triangle in one-third of a turn. Its markings have a wide range of variation like the other figures shown. A 6-pointed star is 2 reversed isosceles triangles superposed. A 5-pointed star, a difficult figure to make prefect, is 2 intersecting equal angles and a straight line. Either of these figures and thousands of others, including polygon shapes, can be described with or without adjustment, according to what is required.

It is a short step from triangulation to mechanical movement. For instance, this combination in itself rectifies the arc-motion of the beam's ends to parallelism and alignment—not approximately straight and parallel like the Watt parallel motion, but mathematically straight, parallel and equidistant. As a practical application, for example, connect a reciprocating piston-rod of a prime mover at *e*, and transfer its motion to, say, the piston-rod of a pump-plunger at *e'*. The job will be complete and perfect in alignment, and likewise a reduction of friction by doing away with cross-heads in slots or slide-ways with their several connecting-rods and bearings. The joints of Fig. 1 may be strengthened and stiffened by broadening the pivots, and the friction still further minimized with pin-center bearings.

It will be observed that to increase the travel of working-centers *e e'* it is only necessary to squeeze the quadrangle *c*, *d*, *e*, *f* into diamond shape, increase the length of controlling member *h* to meet it, and then re-locate center *b* mid-way between *a* and *c*. In Fig. 2 this is illustrated in conjunction with lengthened sides of the quadrangle *c*, *d*, *e*, *f*.



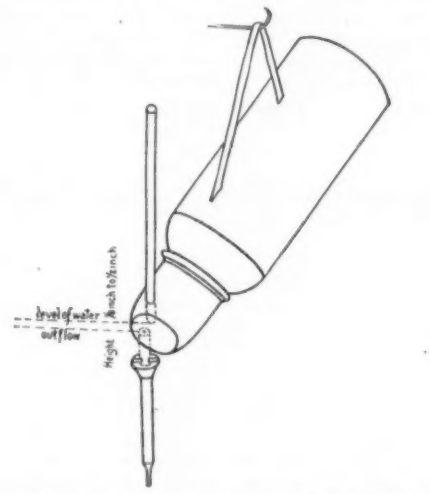
With a few jointed levers actuated circularly or reciprocally, as the case may be, we started with a perfect circle and end with a perfect square, including innumerable irregular diagrams, curves and reverse curves of any radius within the limits of its motion.

Continuous Drop Irrigation From a Thermos Bottle*

Constant dripping from any bottle is as simple in principle as the thermos bottle itself. My interest in working out the construction here presented arises from the fact that for a number of years I have been using small quantities of water, from half an ounce to an ounce a minute, for continuous irrigation and suction, and some time since I succeeded in making the process automatic by means of a constant outflow bottle, an apparatus which demonstrates the elasticity of atmospheric air.[1]

By means of the drop bottle here depicted, a volume of water can be segregated and made to fall in drops into a large vertical tube resembling the glass burette used in chemical laboratories; after which the water becomes absorbed or diffused at the extremity of a small rubber tube, suitable for injections or irrigation, which is attached below. By referring to the illustration it will be seen that an open vertical tube is set in the metallic cap of a thermos bottle, and one eighth of an inch beneath it is a closed tube which is an air chamber and dropper. The upper end of the latter is perforated by a circular orifice (area 0.000829 square inch, which admits a No. 7 sewing needle), and by means of a screw thread it can be depressed.

From the bottle, when filled with hot water, suspended, and tilted to drain it, the flow begins through the circular aperture, emptying the vertical tube first; then air enters in bubbles, and evenly in drops the bottle is evacuated. The tube contains only air when the bottle is partially filled, though the interiors of both are subject to the same atmospheric pressure. They are communicating vessels, but are not at equilibrium. The force which expels the water from the bottle is that of a column of water from one eighth to one half inch in height. The height of the fluid in the bottle



may be said to remain fixed, and by this is meant that when air enters from the open vertical tube, the column is formed, and it extends to the level of the circular orifice, which is changed only to obtain the desired amount of outflow. The efflux is proportional to the square root of the height. Thus, one thirty-second of an inch gives thirty minims, one eighth of an inch, sixty minims, one quarter of an inch, about eighty minims, and half an inch, two drams. Horizontal on a shelf or table is the best position for the bottle on account of the stability thus secured, though there is a residue and the number of drops a minute is slightly less than it would otherwise be, because the point of exit is nearer the level. It is important that the vertical tubes in the cap of the thermos bottle should both have a constant caliber or more; it should be seven sixteenths of an inch, the aim being to avoid capillarity. The writer takes a certain amount of pride in the originality of this device, and feels assured that it will prove to be of considerable practical utility.

The Safety of the Aeroplane

A French publication calls attention to the fact that the loss of life through accidents has been very small among the army aviators, as compared to the records in time of peace, and the explanation is made that in this service only the most skilled men are engaged, and, moreover, they do not indulge in the sensational exhibition tricks that have brought disaster to many. It may be noted that it is this same sensational exhibition business that has given the general public many erroneous and misleading ideas about flying machines that will sooner or later prove an injury to aviation.

* Read before the Lenox Medical and Surgical Society.

[1] "An Air and Water Irrigator and Drain for Prolonged Douching in Deep Cavities," *New York Medical Journal*, May 27th, 1893.

Apple Syrup and Concentrated Cider*

Methods for Economic Utilization of Unmarketable Apples

TWENTY-FIVE per cent of the apples grown in American orchards never figure in the food supply of the nation, according to estimates of specialists who have been studying apple production. These waste apples are either good fruit for which the farmer can find no profitable market and therefore allows to rot under the trees, or surplus culls, left undisposed of after all demands for vinegar and fresh cider have been met. Food conservationists who have long been studying the problem of reducing this waste are inclined to attribute the loss of good fruit, in some measure at least, to defects in existing marketing systems and the failure of orchardists to avail themselves fully of cold storage as a means of keeping fruit from the season of plenty to the season of scarcity and better prices. The problem, however, of turning the culls and the apples too small for retail sale into profit seems to call not for improved marketing conditions but for the transformation of this material into new forms of food.

Although cider making calls for a comparatively inexpensive equipment and involves low labor cost, the mere making of fresh cider will not solve the problem Cider is so perishable that its sale is possible only over a limited period and its principal consumption is during the holiday season. Moreover, fresh cider sells for so low a price and is so bulky that even if it kept well, long-distance shipment of it from the apple fields to the large cities is not profitable. Some of the cider, of course, is converted into vinegar, but the market for vinegar, again, is limited, and vinegar making involves a long period of storage and care and a consequent tying up of capital. Before large additional quantities of cider could be made with profit, therefore, methods of reducing its bulk and of changing it from an article which spoils quickly into one which will keep over a large portion of the year had to be devised.

In the past experiments were largely directed toward attempts to sterilize cider by means of heat. It is simple enough to sterilize cider in this way so that it will keep, but unfortunately the use of sufficient heat to make a stable product destroys the delicate flavor of the fresh juice and makes the product unappetizing. Heated cider has a distinctive cooked taste and can be used only in limited ways, principally in cookery, where it has a certain value.

The problem, therefore, was still unsolved when a series of apple crops larger than the average resulted in an even greater waste than usual and stimulated the Department of Agriculture to institute systematic studies into methods of treating apple juice.

A natural phenomenon, namely, the action of a barrel of cider when allowed to freeze on the farm, suggested that the solution lay here rather than in heating the juice. It was observed that where a barrel of cider was allowed to freeze under natural conditions, the ice formed in a fairly solid mass around the outer sides of the barrel, leaving a core of non-frozen cider which possessed in concentrated form the flavor of the cider, but which contained a far less proportion of water. The outer ice, on the other hand, was mostly water with a very low content of sugar and other solids. Examination of this inner core of unfrozen cider showed that it contained large enough amounts of natural acid and sugar, which act as preservatives, to warrant the belief that concentrated cider would keep longer than ordinary cider and could be marketed after the regular season was over.

The next step was to duplicate as nearly as possible this natural process. By properly governing the freezing method, however, it was found that a more complete separation of the water from the sugar and other apple solids could be obtained. After some experiments, the cider was frozen solid and the ordinary centrifugal machine long used in the sugar industry was employed as a convenient instrument to separate the syrupy portion of the cider from the water-ice by means of rapid whirling. This process, it was found, permitted the reduction of 5 gallons of cider to 1 gallon of cider concentrate, which preserved all the original flavor of fresh cider and could be instantly restored to cider by the simple addition of the water that had been extracted. This product, it was seen at once, was so reduced in volume and weight as to make shipments from apple orchards to the large cities profitable for much longer distances. Laboratory tests bore out the theory that in its concentrated form the cider would keep much longer than in its original condition and, in cold storage, would keep indefinitely. The new product thus promises to make fresh cider available at soda fountains throughout the summer months.

* From the *Yearbook of the Department of Agriculture.*

The next step was to develop this laboratory method so that it could be used commercially in the way described later in this article.

In the meantime, however, having succeeded in concentrating cider to a syrupy consistency, the department began experiments to determine whether it was not possible to make from fresh cider, table syrup, which would be palatable and valuable food and would keep indefinitely in sealed containers, like the syrup made from cane or sorghum. Experiments in boiling the cider concentrated by freezing gave a stable syrup which, however, had a distinctly acid flavor as well as a cooked taste. This, it was thought, might militate against its use on the family table. The problem, it was seen, was to devise a means of removing the excess of acid, known technically as malic or apple acid, from the apple juice without injuring the value of the syrup.

After experiments with various methods of eliminating or reducing the acid, it was found that cider to which carbonate or milk of lime had been added could, after settling or filtering, and boiling, yield a stable and attractive table syrup with a fine flavor. After a year of experiments, conducted in 1914 on a laboratory and factory scale, it was found that it was possible to make this syrup, as later described, in small quantities in the home with ordinary utensils, and that the product when made on a larger scale promised to offer a profitable by-product to steam-power cider mills in regions where there is a large surplus of apples.

METHOD OF MAKING APPLE SYRUP ON THE FARM.

The simplest method of making apple syrup developed by the laboratory is such that the average farm housewife who is provided with a large preserving kettle can readily make a few quarts of the product in her own kitchen. Although she may not find that she can sell her product profitably, she at least will find the method valuable in converting the windfalls of her own farm into a delicate and pleasant syrup for the use of her own family. The method is as follows:

To make 1 gallon of apple syrup, stir into 7 gallons of apple cider 5 ounces of powdered calcium carbonate (carbonate of lime), which is a low-priced chemical, readily obtainable from a local drug store in the form of precipitated chalk or powdered marble-dust. Heat the cider and allow it to boil for a few minutes. As the cider will foam slightly, it is necessary to use a vessel at least one-third larger than the volume of cider. Where a large vessel is not obtainable, the cider may be boiled in batches. Pour the cider, after boiling, into vessels, preferably tall glass pitchers or preserving jars, which permit the condition of the liquid to be observed. Allow the liquid to settle until perfectly clear. This will take several hours or overnight. After the liquid is perfectly clear and shows a distinct sediment at the bottom, pour off the clear portion into the preserving kettle, being careful not to pour off any of the sediment. Add to the clear liquid a level teaspoonful of the carbonate of lime and again stir thoroughly. The process is completed by boiling down the clear liquid. Inasmuch as the liquid when boiling down foams more than on the first heating, the kettle should be only one-third full when boiling commences. When a large kettle is not obtainable, the liquid will have to be boiled down in batches. Allow the liquid to boil rapidly. If the housewife has a candy thermometer, she should allow the liquid to boil until it reaches 220 deg. Fahr. Where no such thermometer is at hand, boil the liquid until it reaches about one-seventh of the original volume, or until a small portion when cooled rapidly and poured from a spoon shows about the same consistency as maple syrup. The aim is to make a thin syrup rather than one that will candy.

When the syrup has reached this point, pour it off into the pitchers or fruit jars and let it stand where it will cool very slowly. Slow cooling is very important in making the syrup clear, as it allows all sediment and added substances to settle out completely. A convenient way of bringing about this slow cooling is to put the vessels into a fireless cooker or to put the jars or pitchers containing the syrup in a wash-boiler, surround them with hot water, and allow the whole to cool. When the syrup has cooled to room temperature there will be found a white sediment, which is known to chemists as malate of lime, a harmless compound of the lime and the acid of the apples. This is identical with the product known as maple sand, which occurs naturally when maple sap is boiled down into syrup. When the settling has been completed, carefully pour off the clear portion of the syrup into a kettle, heat nearly to boiling, and pour hot into sterilized fruit jars, which should be at once sealed as in preserving. Another method would be to pour the syrup cold into the bottles or jars and sterilize and seal just as with fruit. Inasmuch as the sediment at the bottom in no way affects the syrup, those who prefer may at once transfer the boiling syrup from the preserving kettle into sterilized jars or bottles and seal immediately. When using the syrup, simply pour off the clear portion, leaving the sediment, which is not easily disturbed, at the bottom.[1]

The housewife who has made this syrup will find that she has a clear ruby-colored product possibly varying from a deep ruby-red to lighter shades, according to the character of apples used in making the cider. This syrup, which is similar in consistency to maple syrup, can be used like any other table syrup. If made in accordance with these directions it will have a delicate and novel flavor, somewhat similar to that of the sugar which forms when apples are baked. It will be found that children will enjoy it on bread and butter and that it will afford a new and useful flavoring adjunct or sauce for puddings or other desserts.

MANUFACTURE OF APPLE SYRUP ON A COMMERCIAL SCALE.

During the apple-harvesting season of 1914 the department tested out the possibilities of making apple table syrup on a commercial scale in co-operation with a steam-power cider mill at Hood River, Ore. Every effort was made to use methods and appliances which could readily be installed by the average steam-power cider manufacturer who would be willing to invest in some additional equipment. In this experiment 140 gallons of the syrup were manufactured. The process has been made the property of the American people through an application for a public-service patent, which leaves any American citizen at liberty to use the method.

The extra equipment which was found necessary for a steam-power cider mill is: A small steam pump, a plate-and-frame filter press, a small milk cooler or similar cooling device, a 500-gallon settling tank, a 500-gallon receiving tank, and a 500-gallon boiling tank equipped with 30 feet of 2-inch steam coil. In addition there will be required facilities for handling the finished syrup.

In the commercial making of the apple syrup it was found that milk of lime, when properly made up and used, gave more satisfactory results in neutralizing the malic acid of the cider than does the carbonate of lime.[2] Carbonate of lime is recommended for making the syrup in the home, because its use does not necessitate certain chemical tests required in making the syrup on a large scale. These tests, however, are such as any manufacturer of vinegar could make and no more complicated than the usual tests made at creameries for determining the acidity of milk.

After the cider has been collected in the first vat, its natural acidity is tested by the method indicated.[3] A gallon of properly prepared milk of lime is then stirred in with a wooden paddle. A sample of the cider is then tested to determine the degree to which the lime has neutralized the acid. More milk of lime is added until the test shows that the cider is nearly but not quite neutralized. The successive tests should not be neglected, as it is very important that the addition of lime stop before the cider is rendered alkaline, which will ruin it for syrup making. Proper preparation of the milk of lime is essential for success.[4]

[1] Those who wish to make a larger quantity of the syrup and avoid the delay and trouble of the first settling may run the cider, after the first boiling, through a milk separator, which, it will be found, will remove the sediment, which will cling to the inside of the bowl of the separator. The clarified cider then is boiled down, as in the settling method.

[2] Milk of lime, like carbonate of lime, when added in proper proportion to fresh cider combines with the malic acid of the juice to form a fairly insoluble substance known as malate of lime. .This is the white substance which crystallizes out during evaporation and later sinks to the bottom of the storage or settling vat.

[3] The following method is convenient in testing:

Reagents.—(*a*) Tenth-normal sodium hydroxid; (*b*) an alcohol solution containing about 1 per cent of phenolphthalein.

Apparatus.—A graduated 50 cubic centimeter burette, burette stand, a 10 cubic centimeter pipette, and a glass cup or tumbler.

Procedure.—Transfer of 10 cubic centimeters of cider to the glass cup, add a few drops of phenolphthalein, and run in the alkali from the burette until a faint pink color remains after mixing. Note the amount of alkali required to produce the color. Ten cubic centimeters of fresh cider usually require about 8 cubic centimeters of tenth-normal alkali. The vat of cider should be limed until a 10 cubic centimeters portion requires from 0.4 to 0.8 cubic centimeter of alkali.

[4] Unslaked lime containing less than 1 per cent of magnesium, a quality readily obtainable, should be employed. The lime should be "fat"; that is, should slake quickly to form a smooth paste practically free from coarse particles. In slaking the lime add several volumes of water, being careful not to "drown" the lime. If water is added in too large a quantity the lime will become cold and not slake to a cream. After

When the juice has been neutralized to the proper point, stir into it 17.5 pounds of finely bolted, high quality infusorial earth to each 100 gallons of neutralized cider. The purpose of this infusorial earth is to assist in filtering the product, which is the next operation.[5]

The neutralized cider, with the infusorial earth, is then pumped by a small steam pump through a plate-and-frame filter press. This press is a series of deeply corrugated plates covered with filter cloths and separated by frames in such a way that the juice passes through the filter cloths, leaving the suspended matter on the surface of the fiber. Upon experiment it was found that the juice, unless treated with infusorial earth, quickly clogged up the filter press. Infusorial earth retards clogging and permits the rapid filtration of the product. When filtration becomes slow, the cloths should be changed.

The filtered juice is then delivered into a 500-gallon receiving vat, whence it can be drawn as needed into the evaporating vat. As the liquid foams considerably on boiling, the vat wall should be at least 3 feet higher than the surface of the liquid. The evaporating vat should be provided with a flat spiral of 2-inch block tin or silver-surfaced copper pipe, having at least 30 linear feet of effective heating surface. With a steam pressure of from 60 to 90 pounds, this coil will reduce 125 gallons of limed cider to a syrup in about 1½ hours. The boiling is continued until the thermometer registers about 220 deg. Fahr. The steam is then shut off and the syrup is discharged through a valve in the bottom of the vat. The boiling should not be prolonged more than 2 hours, and for this reason it is wise not to introduce more than 125 gallons of juice into a vat equipped with a coil of this size.

The hot juice is passed over a small milk cooler or a series of pipes through which cold water flows, and from the cooler into the settling vat. The purpose of this is to reduce the syrup quickly to a temperature of about 160 deg. Fahr. If the syrup were put at a boiling temperature into the settling tank, it would cool very slowly and undergo serious changes in flavor. At the same time, the preliminary cooling should not be carried too far, because if the juice is suddenly cooled much below 160 deg. Fahr., the separation of the malate of lime formed from the milk of lime and the malic acid of the juice will be retarded and the excess of malate lime will remain in the syrup, giving it an acrid taste.

In the storage vat the syrup is allowed to cool slowly and settle. At the end of a few days it will be found that the malate of lime has settled to the bottom of the tank in a compact layer, leaving the syrup quite clear. The more time allowed for settling, the clearer will be the syrup. When the syrup has settled sufficiently, it is drawn out by means of a tap placed above the sediment line, or siphoned off, into bottles or other containers. To insure sterilization it may again be brought to the boiling point and put while still hot into containers and sealed, or other common methods of sterilizing such products in containers may be followed. If the setling has not been complete, the syrup after being reboiled and allowed to stand may show a slight sediment of malate of lime, which is similar to the maple sand of maple sap. The syrup can be again poured off from the sediment, or the sediment, which does no harm, may be left in the container.

CONCENTRATION BY FREEZING AS A FALL ACTIVITY FOR ICE AND COLD-STORAGE PLANTS.

During the apple-harvesting seasons of 1913 and 1914 the department experimented extensively on a commercial method of handling fresh cider so as to reduce its bulk to a point where longer shipment would be possible and also to secure a product that would keep better and could thus be sold over a longer period than is possible with ordinary apple juice.

Analyses show that ordinary cider contains from 12 to 14 per cent of solids, mostly sugars, which make up from 10 to 12 per cent, and malic acid. The remainder of the cider is water, which experiment quickly showed can be withdrawn by freezing. Replacing the water so removed with ordinary drinking water will restore the cider to its original quality.

After varied experiments it was found that 5 gallons of cider could be reduced by freezing and treatment to 1 gallon of syrupy cider concentrate. To test the keeping quality of the concentrated cider, it was kept under various conditions. It was found that while the concentrated cider would not keep indefinitely under household conditions, its larger percentage of sugars and acids kept it from fermenting as quickly as ordinary cider. When kept cool, as in a household refrigerator, concentrated cider, it was found, would not spoil for many weeks. When kept at or below 32 deg. Fahr. in cold storage it was found that concentrated cider could be kept from one season to the next and thus make fresh cider available as a beverage during the summer months. The department made experiments on a commercial scale in concentrating apple juice by freezing during the apple-bearing seasons of 1913 and 1914. This work was done in connection with a cider mill located near a commercial ice-making plant in the apple-growing regions of Oregon. These experiments, in which the cider of over 4 tons of apples, or 600 gallons, was concentrated, seem to indicate that the product can be made at a cost which should yield an excellent profit to an ice plant during its slack season. The chief advantage to an ice plant, near an apple section, of freezing and concentrating cider as a by-product is that it will give it an activity at the very season when the demand for ice is greatly diminished because of the approach of cold weather.

The actual cost of the finished product will, of course, vary with the cost of the raw materials, rates of wages, and the actual cost of refrigeration, which, in turn, depends on the price of coal and other factors. The method calls for but slight additions to the equipment of the ordinary ice-making or cold-storage plant. The department is not ready to recommend the erection of freezing plants merely for the handling of the fall business of freezing cider, but recommends the process only to existing plants near large orchards which will find it a convenient filler and a means of reducing their overhead expenses through keeping their plant busy at an otherwise dull season. Moreover, as the product has not yet been marketed on a commercial scale, those undertaking the process should first satisfy themselves that they have a ready and convenient outlet for their product. A brief description of the manufacture of this concentrated cider on a commercial scale follows:

An ice-making plant was equipped with special 300-pound tin-lined freezing cans,[6] an ice crusher, a centrifugal machine, necessary machinery for handling the frozen cider, and containers for the finished product.

The fresh cider is placed in the tin-lined ice cans and frozen in the brine tanks of the ice-making plant. For the first freezing the brine temperature should range between 10 deg. and 20 deg. Fahr., which will freeze the cider into a solid mass in from 36 to 48 hours. The frozen cider is then loosened from the cans by removing it from the brine tanks, thawing it at the sides and bottom, and dumping it, just as ice is removed from the cans in ice making. The blocks of frozen cider are then passed through a power ice crusher which breaks them into pieces no larger than a walnut.

The crushed frozen cider drops from the crusher into a standard sugar centrifugal machine which provides a mechanism for rapidly whirling it, and thus separating the syrupy part from the water ice, just as in the case of sugar, where the molasses is whirled off from the crystallized sugar. The frozen cider drops into the perforated metal basket[7] of the machine. This basket, which is whirled rapidly, causes the syrupy part of the cider to fly off from the mass of ice into the collecting chamber opening into the collecting tank below. A centrifugal operating at about the same speed used on sugar will separate most of the syrupy content from a charge of ice in 3 minutes.

The partially concentrated cider in the receiving tank is then put again into the freezing cans and refrozen at a temperature from 0 deg. to 10 deg. Fahr., which will refreeze the syrupy cider in from 2 to 3 days. The refrozen cider does not become very solid and can readily be removed from the cans without thawing. It is passed through the crusher and again whirled in the centrifugal machine and reaches the receiving chamber as a fairly thick, somewhat viscous syrup. One gallon of this syrup represents 5 gallons of the original cider, which means that nearly 4 gallons of water have been removed by freezing and centrifugalizing.

As the ice remaining in the centrifugal basket still contains some of the sugar and solids of the cider, it may be removed from the basket by use of the unloader provided, allowed to warm up slightly, and again be run through the centrifugal machine. This will remove practically all the valuable material. As there will now be less than 1 per cent of apple solids left in the ice, it probably does not merit further treatment. The concentrate obtained on the second centrifugalizing of the ice is somewhat richer in solids than ordinary cider and may be added to the fresh cider or refrozen and treated as fresh cider.

The fully concentrated cider will be a somewhat thick liquid with the cloudy appearance and color of unfiltered fresh cider. If kept sealed at household refrigerator or in cold-room temperatures, it will keep for weeks. Where allowed to become warm, it will gradually ferment, but will spoil much more slowly than ordinary cider. Concentrated cider intended for use during the following Spring or Summer should be put into cold storage at once and kept at or below 32 deg. Fahr. It can be shipped anywhere in Winter weather in unheated cars without danger of spoiling. It can be bottled, canned, or shipped in clean kegs. Inasmuch as 1 gallon can represents 5 gallons of cider and the equivalent of 250 gallons of fresh cider can be put in a 50-gallon barrel, the concentrated product can be shipped profitably for much longer distances to market than can the bulky fresh cider. In addition to saving 80 per cent on the freight, the reduction in volume permits the shipper to use containers one-fifth the size, which is an important saving in cooperage. The saving in containers, which have always been relatively expensive items in shipping cider, should alone nearly offset the cost of freezing and concentration. In addition there is the saving of drayage and other handling costs. On its arrival at the market the retailer can at once restore it to cider by adding 4 parts of water, or he can sell it in the convenient concentrated form to his customers. Moreover, as has been explained, this cider, instead of fermenting on the journey, or a day or two after its arrival, will keep for two or three weeks in closed containers if not allowed to get warm and if kept closed in an ice box or refrigerator will remain in good condition for five or six weeks. The cider in its concentrated form is useful also as a flavoring syrup for desserts. When stored at low temperatures, the concentrated cider will keep indefinitely. In this way concentrated cider made in the Fall can be kept over and used in the soft-drink trade during the hot months, at soda fountains, and in the home.

Those who wish to make a clear, brilliant cider concentrate can filter it by adding to the concentrated product 3 per cent or more by weight of infusorial earth, which should be thoroughly stirred in. This mixture can then be pumped through a plate-and-frame filter press, such as has been described in connection with the manufacture of apple syrup.[8]

The Unsolved Mystery of Why the Stomach Does Not Digest Itself

IT has often been questioned why the stomach does not digest itself. Proteids in the shape of tissues of other animals rapidly dissolve when introduced into the gastric juice but the stomach tissue itself is never attacked by its own gastric juice. Among the various reasons that have been suggested are the protective influence of the mucous secreted along the digestive canal, and the existence of anti-enzymes, which counteract the activity of the digestive juices. Neither of these theories has, however, been accepted as capable of explaining the complete and continued immunity of the digestive tract to digestion. It cannot even be asserted that it is simply because these tissues are alive that they are thus protected, since the living mucous membrane of the urinary bladder, for example, is dissolved by the pancreatic or gastric juice of an animal of the same species. Even the living mucous membrane of the intestine is apparently digested by the gastric juice of the animal to which it belongs if food is not introduced at the same time. The protection of living tissues to digest fluids is thus limited. On the other hand, however, some aquatic forms of life, such as protozoöns, worms, crustaceans and insects have been kept alive at times for a month, in a solution of trypsin that would quickly have dissolved a mass of dead protein.

So a correspondent to the *Journal of the American Medical Association* for July 18, 1914, concludes that the continued immunity of the mucous membrane of the stomach to an active gastric secretion and of the intestinal mucous membrane to pancreatic juice still remains a mystery. Some unknown protective power of adaptation under certain circumstances must be admitted as one of the innumerable factors of evolution of which we are still ignorant.—*H. W. S. in Science Conspectus.*

slaking, let the mixture cool down, and then, with the addition of more water, work it to a thin cream and strain this through a fine wire screen to remove coarse particles. Freedom from coarse particles is essential, as these if present would sink to the bottom of the vat and continue to act and render the juice alkaline.

[5] Infusorial earth, also called diatomaceous earth, or kieselguhr, consists of nearly pure silica built up of the skeletons of microscopic sea animal called diatoms. When crushed and bolted it therefore exposes an enormous surface to liquids with which it is mixed. It possesses the property of opening up the slime which collects on the filter cloths, which otherwise would choke and render filtration impossible. Infusorial earth possesses this property to an extent not possessed by any other known substance. At the same time it is so inert that neutral or acid substances can be filtered through it practically without contamination. It is extensively mined in the United States, and may be had finely bolted, ready for use in filtering, in carload lots at less than 2 cents a pound.

[6] It is essential that tin-lined freezing cans be employed, as they resist the action of the cider successfully and are the cheapest form of freezing cans which will serve the purpose. Galvanized cans are quickly attacked by the cider and should never be used.

[7] As the cider is very subject to metallic contamination, care should be taken to avoid using a centrifugal basket with brass lining. An unlined steel basket is satisfactory.

[8] It is well to paraffin the iron surfaces of the filter press before using it for filtering the cider concentrated by freezing, to lessen contamination with iron. This can be easily accomplished by heating the press with steam to above the melting point of paraffin and then rubbing on the paraffin, working it into the crevices with the aid of a brush.

Gaint Artillery of Fifty Years Ago

THE increase in the size of artillery in modern times, as shown in the reports from the war, are so startling that it is interesting to turn back some years and compare the products of a previous generation with the present. This is done in the following article that appeared recently in the *London Daily Telegraph*.

There are the days of the big gun—of ponderous ordnance on land and sea. Yet, curious to say, half a century ago England produced a weapon which threw a projectile greater in weight and larger in diameter than any which has been made since.

The story of the giant 36-inch mortars of 1855–58, which threw a ball 36 inches in diameter and a ton in weight, is full of detail of extraordinary interest. It is a story, too, of triumph and failure, in the face of all the difficulties of new experience.

England was at war in the Crimea. A great Prime Minister was at the head of the Government in the person of Lord Palmerston, and to him went on engineer, Robert Mallet, with his proposal for the construction of a huge mortar with which to help the Allies.

The inventor made good his case, and, with characteristic energy, Palmerston addressed a letter to the Lieutenant-General of the Ordnance in the following terms:

"I am so fully satisfied with the probable success of Mr. Mallet's scheme that I am willing to take upon myself, as First Minister of the Crown, the full responsibility of carrying it into execution; and I, therefore, request that you will, without the slightest delay, take the necessary steps for the immediate construction of two mortars upon the plan proposed. . . Time is an essential element in this matter, and months have already been lost in needless hesitation."

This letter was written on May 1st, 1855, and six days later the firm of Mare, of Blackwall, submitted their tender to supply two mortars, built to the specification drawn up by Mr. Mallet. The firm promised to deliver the mortars, within ten weeks of the receipt of the order, at a cost of £4,900 each, including the mortar beds. If the weight of the mortars exceeded thirty-five tons each, they were to receive further payment at the rate of £140 per ton. The Board of Ordnance had been given sufficient impetus in the matter by Lord Palmerston's letter, and Messrs. Mare's offer was accepted on the following day.

Sad to relate, however, the huge weapons were not completed until a year after the termination of the Crimean War. Instead of ten weeks, the time occupied in construction was no less than ninety-six weeks, and the mortars were not delivered until May, 1856. The delay was due partly to the bankruptcy of the contracting firm, but mainly to the unexpected difficulties encountered in the constructional work. When they were complete the two mortars were the combined work of three different firms.

Each of the Mallet 36-inch mortars weighed no less than forty-two tons, and had a length of nearly 13 feet. Beside a modern 13.5-inch naval gun, weighing some eighty tons and measuring over 50 feet in length, these figures may not sound very extraordinary, but we have to remember the fifty years which have passed since the days of these wonderful old pieces of ordnance.

The mortars were said to be the first embodying the principle of "ringed structure" in ordnance, and were built up as follows: The base, carrying the trunnions—the cylindrical projections which are supported by the cheeks of the carriage—was of cast iron, 30 inches thick, and weighing seven and a half tons.

The wrought iron breech-piece was 70 inches long, and weighed seven tons. This was strengthened externally by two layers of wrought iron hoops and a heavy ring. Into the breech-piece was bored the powder chamber, 48½ inches deep; this was cored from 14 inches to 9 inches in diameter.

The body itself consisted of three compound rings of wrought iron, finishing with a solid ring at the muzzle. These compound rings consisted of twenty-one, nineteen, and eleven hoops respectively, the first-mentioned being next to the breech-piece, where the greatest powder stresses were felt. The largest hoop employed was 67 inches in diameter, the smallest 40 inches. To give additional strength six wrought-iron bolts, nearly square in section, ran from the ring at the muzzle to the cast-iron base.

The mortar-bed, to which the monster weapon was attached, was provided with a screw arrangement which allowed the mortar to be elevated at any angle from 40 degrees to 50 degrees.

With the mortars fifty shells were delivered, these being contracted for at the rate of £16 per ton. The shells were spherical and of cast iron. They were cast over cores consisting of two hemispheres, in which the bursting charge could be accommodated. Each shell was provided with a fuse.

Mr. Mallet had calculated that a bursting charge of 480 pounds of powder could be used with the shell in actual warfare. At practice sand and sawdust were substituted to fill the space within the hemispheres.

Much delay was experienced before the trials of the new ordnance could be carried out, and it was then decided that only one mortar should be used. The other mortar constructed was never fired, and was afterward erected at the Royal Arsenal, Woolwich, where it remains to this day an object of much interest to the visitor.

Plumstead Marshes were selected as the venue of the trials. Those privileged to witness the firing were much impressed by the ponderous, but majestic, flight of the great one-ton balls through the air. The velocity of the huge shells was in the neighborhood of but 300 feet or 400 feet per second, so that their flight could be readily followed. The trajectories of the projectiles resembled in a marked degree those of trench howitzers, such as the German "Minenwerfer," which are being used in the great conflict on the Continent.

Preparations for the trials were not complete until October 15th, 1857. The platform for the accommodation of the mortar cost £150, and the foundation of Dartford gravel, which it was found necessary to make to receive the platform, cost £300.

Firing was carried out on four days, extending over a period of more than nine months. The delay was due to mishaps with the mortar; for instance, after the fifth round was fired, repairs costing £56, and taking two months to carry out, had to be effected. Details of some of the rounds fired are interesting, and may now be given.

The trials opened cautiously. The first round was fired with a modest charge of 10 pounds of powder, but the shell weighed 2,376 pounds. The elevation given to the mortar was 48 degrees 20 minutes, and a range of 370 yards was obtained. The shell was afterward found entire at a depth of 6½ feet, to which it had penetrated in the soft ground of the marshes.

The second round was fired with a charge of 20 pounds of powder. The elevation was the same as with the first round, and the 2,362 pound shell covered 900 yards in 13 seconds. This shell was not found after digging down 12 feet, and it was impossible to locate it then, even with a 9-foot probe.

Thirty pounds of powder were used in the third round. The shell this time exceeded the ton by 156 pounds, and ranged 1,277 yards in 17 seconds, with an elevation of 48½ degrees. After digging 18 feet down, no trace of the shell was found, and even at that depth the 9-foot probe failed to touch it.

Altogether nineteen rounds were fired, but only the first shell fired was actually located. Colonel Walpole, the commanding engineer, was of opinion that the majority had buried themselves fully 30 feet below the surface. And there they remain to this day. It was estimated that to recover the weighty globes would have entailed an expenditure of no less than £21 apiece.

The greatest range obtained with the mortar was at the nineteenth and last round, fired with a charge of eighty pounds of powder. The 2,395-pound shell attained a range of 2,759 yards; that is, a little over one and a half miles, in 23 seconds at 45 degrees elevation. With this large charge the mortar recoiled only 15 inches. The heaviest shell fired at the trials was one weighing 2,986 pounds; it had a range of just under the mile.

Such is a short account of one of the most remarkable products of artillery genius in this country. Circumstances prevented the actual employment of the huge mortars in warfare, but, as a celebrated artillery officer, the late General Lefroy, remarked: "Few will doubt that if the mortars had been completed in time, and Lord Palmerston's intention to send one to the Baltic and another to the Black Sea had been carried out (and designs for mortar rafts had been actually prepared by Mr. Mallet), it would have been perceived that a new power had entered the European arena."

Big Electric Generators

IN an article in the *Electric Journal*, B. G. Lamme, chief engineer Westinghouse Electric and Manufacturing Company, commented on direct-current generators as follows: The engine-type machine in its prime was a magnificent piece of apparatus. On account of its low speed it was of comparatively large dimensions for a given output. In the largest capacity low-speed engine-type generators, over-all dimensions of from 25 feet to 27 feet were attained. However, these machines were midgets, both in size and capacity, alongside some of the alternating-current engine-type generators. The latter were constructed up to capacities of from 5,000 to 6,000 kilowatts compared with 3,000 kilowatts for direct-current, while the engine-type alternators attained over-all diameters as high as 42 feet. Incidentally, as regards capacity alone, the race between alternators and direct-current machines has been very much one-sided, almost since the polyphase system became thoroughly commercial. The earliest Niagara generators—constructed in 1893—of 3,750 kilowatts, were practically of as large capacity as the largest direct-current machine ever built; while in later polyphase work, generators of the usual multipolar construction have been built up to 17,000 kilowatts and turbo-generators up to 30,000 and 35,000 kilowatts. Obviously, as regard maximum capacity, the direct-current generator makes but a poor comparison, but this should in no way detract from the appreciation of this machine.

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Table of Contents

	PAGE
The Resurrection of Babylon.—By C. J. Ball.—11 illustrations	68
The Galvanic Cell That Reverses Its Polarity When Illuminated	66
Lime Burning	67
The Construction of a Multiple Tuner.—By C. L. Sears.—10 illustrations	68
The Medicine of the Old Testament.—By Stewart B. Blakely	70
Geology in Relation to the Exact Sciences	73
Recent Progress in Astrophysics.—III.—By Prof. C. G. Abbot	74
Larger Ions in the Air	75
Acquired Radio-activity	75
The Uniflow Steam Engine.—3 illustrations	76
Aid to Astronomical Research	76
Suggestions in Mechanisms.—By S. D. Mott.—3 illustrations	77
Continuous Drop Irrigation from a Thermos Bottle.—1 illustration	77
Safety of Aeroplanes	77
Apple Syrup and Concentrated Cider	78
The Unsolved Mystery of Why the Stomach Does not Digest Itself	79
Giant Artillery of Fifty Years Ago	80
Big Electric Generators	80

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lway,
ork, N. Y.

PAGE
illus- 66
a Illu- 66
..... 67
ars.— 68
rt B. 70
..... 71
C. G. 74
..... 75
..... 75
..... 76
..... 76
ustra- 77
le.—1 77
..... 77
..... 78
e not 79
..... 80
..... 80